An Assessment of the First Four Years of the Environmental Water Account: One Scientist's Opinion

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Introduction

The Environmental Water Account (EWA) is an innovative approach to managing water and fishes in the Sacramento-San Joaquin Delta (hereinafter, Delta) (Figure 1) and its watershed (Figure 2). An essential goal of the CALFED Bay-Delta Program (CALFED 2003; http://calwater.ca.gov) is to increase water supply reliability to water users while at the same time assuring the availability of water to meet fishery protection, restoration, and recovery needs as part of the overall Ecosystem Restoration Program (http://calwater.ca.gov/Programs/EcosystemRestoration/Ecosystem.shtml). The EWA is designed to protect fish, using water purchased from willing sellers, thereby providing assurances that water delivered under baseline conditions will not be interrupted because of crises involving listed species of fish. The EWA primarily focuses on resolving the conflict between fish protection and water diversion at the federal Central Valley Project (CVP) and State Water Project (SWP) pumps in the southern Delta (Figure 1) because, in recent years, these diversions have been subject to the greatest variability in reliability due to conflicts with fishery protection needs.

[Figure 1 near here]
[Figure 2 near here]

The EWA was implemented as a four year experiment, starting in Water Year (WY) 2001[1] and ending in WY 2004. As the trial period comes to an end, EWA is being subject to a variety of assessments to determine the level of success achieved. The EWA Science Advisors, with the support of the CALFED Science Program, commissioned this report. The Science Program provided funding through an existing agreement with the author. The objective of the report is to provide a general assessment of the EWA from the perspective of a local fisheries scientist with a general knowledge of the important fisheries and ecological issues but no direct involvement in the EWA Program. The general approach for the assessment was for the author to review the body of documents describing the EWA trial period and provide comment on any and all aspects of the EWA; however, the focus is on the scientific, and particularly the biological, aspects of the EWA. This assessment is not meant as a detailed quantitative review of any aspect of the EWA; thus, the observations represent the qualitative professional opinion of the author. In particular, there is no attempt to evaluate the specific decisions made by EWA biologists about when and where to use water as the EWA operated in real time. The intent of the assessment is to provide useful feedback to those responsible for managing the EWA, which presumably will continue, and to those stakeholders with an interest in the EWA.

[1] A water year actually starts in October of the previous year and ends on 30 September of the subject year.

Methodology

The author reviewed a variety of documents associated with the EWA (see EWA Documents Reviewed). Personal communications by a variety of methods (e-mail, oral communications, or written comments) were utilized to solicit additional information on particular issues. Primary contacts at the time of this draft have been the EWA Science Advisors (Randy Brown and Wim Kimmerer), CALFED Science Program staff (Zachary Hymanson), and EWA staff (Jim White and Victoria Poage). A limited amount of background information is presented for readers unfamiliar with the Sacramento-San Joaquin Delta. Sources of more detailed information are identified as appropriate. Current plans are to continue to revise the report in response to written and oral comments on this and subsequent drafts. A final report will be submitted to Science Program in 2005.

Background

The San Francisco Estuary (Estuary), of which the Delta is a part, is the largest estuarine system on the west coast of North America and drains approximately 40% of the surface area of California. The Estuary has been highly altered by anthropogenic activities with consequent changes in physical and ecological processes (Conomos 1979, Cloern and Nichols 1985, Hollibaugh 1996) and native fish populations (Bennett and Moyle 1996, Moyle 2002). One consequence of these changes is that a number of native species of fish have been listed or considered for listing under state and federal endangered species legislation (Table 1). Water diversions from the Delta and associated entrainment of fishes are mentioned as “threats” to the species in most cases.

[Insert Table 1 here]

The environmental and institutional background for the EWA has been described in detail by others (e.g., Brown and Kimmerer 2001a,b); however, a brief summary is necessary to understand how the water management system works and how the EWA functions within that system. In California most precipitation falls in the mountains as snow during the winter, with subsequent snow melt leading to a large sustained spring peak of snowmelt runoff. This hydrologic pattern is not compatible with the pattern of human needs. Municipal and industrial needs for water are more or less constant through the year and the needs of agriculture are greatest during the summer when water is needed for irrigation. This mismatch between supply and demand led to the development of a complex water management system involving a variety of public agencies, ranging from local irrigation districts to large state and federal agencies. The general strategy is to capture the spring snowmelt runoff in reservoirs in the foothills of the mountains and then release that water for downstream use and diversions during the remainder of the year. The two major water projects are the Central Valley Project (CVP), operated by the U.S. Bureau of Reclamation (BOR), and the State Water Project, operated by the California Department of Water Resources (DWR).

The CVP is the older of the projects, dating back to the 1940s. Major storage facilities include Shasta Dam on the Sacramento River, Folsom Dam on the American River, Friant Dam on the San Joaquin River, New Melones Dam on the Stanislaus River, and the Trinity Project on the Trinity River (Figure 2). The Trinity Project actually transfers water from the Trinity River drainage to the Sacramento River drainage, where it is stored in Whiskeytown Reservoir, then released into the Sacramento River. Major transfer and diversion facilities are located in the Delta, including the Contra Costa Canal, the Delta Cross Channel, a pumping facility in the south Delta near Tracy (CVP pumps), and the Delta-Mendota Canal.

The SWP was constructed in the 1960s. Oroville Dam on the Feather River provides storage exclusively for the SWP (Figure 2). The major transfer facility is a pumping facility in the south Delta, very near the CVP pumps. Unlike the CVP pumps, the SWP pumping facility has a forebay (Clifton Court Forebay). In addition, the SWP includes two joint use facilities (SWP and CVP). The San Luis Dam and Reservoir complex provide south-of-Delta storage capacity for both projects (Figure 2). The San Luis Canal is a joint use 101-mile section of the California aqueduct extending to the south from O'Neill Forebay. San Luis Reservoir has no natural watershed. Water is pumped from the Delta and into the reservoir for storage and release later in the year when inflow to the Delta and pumping rates are low.

The CVP and SWP pumping plants are large enough that their combined capacity can pump more water out of the Delta than is flowing in from rivers and streams. This can result in net flows moving across the Delta to the pumps rather than out into Suisun Bay. The situation is actually more complex than this because the Delta is subject to tidal action. The tidal flows are actually much larger than the net flows into or out of the Delta and result in complex hydrodynamic patterns. Both the CVP and SWP pumping plants have large fish screening facilities. These facilities divert fish out of the channels leading to the pumping plants. The diverted ("salvaged") fish are placed in trucks and transported to release points in the Delta. The diverted fish are subsampled to provide estimates of the number of fish affected by pumping plant operations. The efficiency of these facilities is highly dependent on the size and behavior of the many species of fish present (see Table 2 for a species list). There are also believed to be significant sources of pre-screen mortality, primarily predation by large fish on small fish, particularly in Clifton Court Forebay.

The actual day-to-day operations of the projects are extremely complicated; however, the basic idea is straightforward. During the spring, when water is relatively abundant, the pumping plants are used to supply both water needs and to provide water for storage in San Luis Reservoir. During the remainder of the year, water stored in reservoirs in the Sacramento River drainage is released for delivery to the pumping plants in the Delta. Similarly, the water stored in San Luis Reservoir is released as needed to help meet south of the Delta water demand. Unfortunately, the spring is also the time period when salmonid and delta smelt juveniles are present in the Delta (Table 3). In addition, mature adult delta smelt are present in the Delta during the winter as they migrate into the Delta to spawn, as are juveniles of some salmonids. Pumping when fish are present near the pumps can result in entrainment of fish into the pumping plant. The resulting conflict between fish protection required by endangered species legislation and associated regulatory agreements (e.g., biological opinions) and the need for reliable water supplies for human uses eventually led to the establishment of the CALFED Bay-Delta Program, including the EWA.

Goals of the EWA

A major goal of the CALFED Program is to provide increased water supply reliability to water users while assuring the availability of sufficient water to meet fishery protection and restoration/recovery needs as part of the Ecosystem Restoration Program. The EWA was established as one means to achieve this goal, as part of the CALFED Record of Decision (ROD; CALFED 2000). As stated in the ROD, the EWA focuses on resolving the fishery/water diversion conflict at the CVP/SWP Delta export pumps because, in recent years, these diversions have suffered the greatest fluctuations in water supply reliability due to conflicts with fishery needs (CALFED 2000). The CALFED agencies drafted the EWA so that it has no effect on the water rights of other water right holders in the watershed (see Assets and Tools sections). The stated purpose of the EWA in the ROD is as follows:

> "The EWA has been established to provide water for the protection and recovery of fish beyond water available through existing regulatory actions related to project operations. The EWA is a cooperative management program whose purpose is to provide protection to the fish of the Bay-Delta estuary through environmentally beneficial changes in SWP/CVP operations at no uncompensated water cost to the projects' water users." (CALFED 2000, pg. 54)

The EWA was actually established contemporaneously with the ROD by a separate agreement, the Environmental Water Account Operating Principles Agreement (OPA), executed by the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), California Department of Fish and Game (DFG), U.S. Bureau of Reclamation (BOR), and California Department of Water Resources (DWR). In the OPA these agencies were divided into two groups, the "fish management agencies" or MAs (USFWS, NMFS, DFG) and the "water project agencies" or PAs (BOR and DWR). The MAs were charged to manage the EWA assets and exercise their biological judgment to identify SWP/CVP operational changes beneficial to the Bay-Delta ecosystem and/or the long-term survival of fish species, including those listed under the State and Federal Endangered Species Acts. The PAs were charged to cooperate with the MAs in administering the EWA and making the operational changes proposed by the MAs. The description of the OPA is similar to that in the ROD (CALFED 2000):

> "The EWA is a cooperative management program whose purpose is to provide protection to the fish of the Bay-Delta estuary through environmentally beneficial changes in the operations of the State Water Project (SWP) and federal Central Valley Project, at no uncompensated water loss to the projects water users. The EWA is intended to provide sufficient water, combined with the Ecosystem Restoration Program and the regulatory baseline, to address CALFED's fishery protection and restoration/recovery needs." (ROD, Attachment 2, 2000; pg. 1).

These general statements of purpose are not particularly useful as day-to-day operational objectives. In fact, the immediate management objectives seem to have been derived from the baseline or "Tier 1" protections described in the ROD. The EWA is intended for fishery protection actions supplemental to the baseline level of protection established by existing regulatory programs. The three tiers of protection described in the ROD (CALFED 2000) include the following:

- Tier 1 is baseline water, provided by existing regulation and operational flexibility as described above. The regulatory baseline consists of the biological opinions on winter-run salmon and delta smelt, 1995 Delta Water Quality Control Plan, and 800 TAF of CVP Yield pursuant to CVPIA Section 3406(b)(2).

- Tier 2 consists of the assets in the EWA combined with the benefits of the ERP and is an insurance mechanism that will allow water to be provided for fish when needed without reducing deliveries to water users. Tier 1 and Tier 2 are, in effect, a water budget for the environment and will be used to avoid the need for Tier 3 assets as described below.

- Tier 3 is based upon the commitment and ability of the CALFED Agencies to make additional water available should it be needed for Endangered Species Act (ESA) requirements. It is unlikely that assets beyond those in Tier 1 and Tier 2 will be needed to meet ESA requirements. However, if further assets are needed in specific circumstances, the third tier will be provided. In considering the need for Tier 3 assets, the fishery agencies will consider the views of an independent science panel. Although the CALFED Agencies do not anticipate needing access to Tier 3 of water assets, the CALFED Agencies will prepare an implementation strategy for Tier 3 by August 2001 (see below for whether this was accomplished), establishing a timely scientific panel process and identifying tools and funding should implementation of Tier 3 prove necessary.

In practice, the EWA Tier 2 protections have generally been used to provide additional protection for winter-run Chinook salmon, delta smelt, and other listed anadromous salmonids, including spring-run Chinook salmon and steelhead rainbow trout. Thus, EWA actions are deemed successful if incidental take of the listed species is reduced from the levels that would have occurred without EWA actions. More nebulous benefits to other species, the Bay-Delta ecosystem, and species recovery are generally assumed to occur whenever an EWA action is taken. This focus on relatively defined practical objectives (i.e., reduced salvage of listed species) was reasonable for the initiation of the program. Whether this focused objective remains reasonable for a continued long-term program is open to debate (discussed below). Evaluations of the success of the first 4-years of EWA often cite the increased cooperation between the MAs and PAs as a measure of the success of the program. While increased cooperation and reduction of conflict has certainly been a beneficial outcome of EWA, it should not be considered a measure of the success of the program. Both the ROD and OPA state that the EWA **will be** (emphasis added) cooperative rather than stating this as a goal.

The EWA EIS/EIR (2004) implies an institutionalization of the focus on listed species. While acknowledging the original objectives put forth in the ROD and OPA, the EWA is described as having two primary elements: (1) assisting in fish population recovery for at-risk native fish species; and (2) increasing water supply reliability by reducing uncertainty associated with fish recovery actions. In addition, the EIR/EIS describes 5 characteristics that a successful EWA must have:

1. protect the at-risk species affected by SWP/CVP operations and facilities,
2. contribute to the recovery of these species,
3. allow timely water-management responses to changing environmental conditions and changing fish protection needs,
4. provide reliable water supplies to water users in SWP/CVP export areas, and
5. not result in uncompensated water loss to users.

These descriptions of primary elements and program characteristics suggest that the original general goal to provide protection to the fish of the Bay-Delta estuary through environmentally beneficial changes in the operations of the State Water Project (SWP) and federal Central Valley Project has been de-emphasized. This may be a practical response to stakeholder desires for fulfillment of the regulatory requirements of endangered species legislation (e.g., Swanson 2001, 2002) and demonstration of the cost-effectiveness of the EWA in recovering listed species.

Tools and Assets of the EWA

The EWA is basically a water management program designed to meet the goals discussed above. The OPA charges the MAs and PAs to take a number of actions to acquire the initial water (assets) required for the first and subsequent years of EWA. The OPA also describes a set of “tools” for obtaining EWA assets and the minimum level of assets that constitute an operational EWA. An operational EWA is defined in the OPA as occurring when the following conditions are met:

1. a one-time 200,000 acre-feet of stored water equivalent has been acquired;
2. the EWA includes deposits of 185,000 acre-feet of purchased water;
3. the EWA includes a source-shifting agreement of at least 100,000 acre-feet; and
4. variable tools are all in place.

Condition 1 was to be met through a one-time acquisition by the PAs of 200,000 acre-feet of stored water or its functional equivalent from south-of-Delta sources. This water was intended as collateral for borrowing, to be released only when all other assets had been expended. The related storage space was intended to function as long term storage space, including after the water had been released.

Condition 2 was to be met each year by purchasing from willing sellers, 150,000 acre-feet of water from sources south of the Delta and at least 35,000 acre-feet of water upstream of the Delta or their functional equivalents. It was recognized that the upstream-of-Delta purchases might grow in subsequent years. The purchases were to be arranged such that the assets could be kept in storage until they were used or transferred to other EWA storage facilities. Storage space can include both surface water reservoirs and groundwater basins.

Condition 3 was to be met by the PAs arranging with one or more contractors to use water totaling at least 100,000 acre-feet from either an alternate source, or at a subsequent time, to allow for storage of the project water in San Luis Reservoir as an asset or to enable an operational curtailment of pumping without causing a summer "low-point problem". The EWA was to repay this water each year during the 4-year pilot. The "low-point problem" refers to draw down of San Luis Reservoir to the point that water quality problems occur in deliveries to Santa Clara Water District (Brown and Kimmerer 2001a).

Condition 4 required that additional tools were in place to provide additional EWA assets but the amount of water expected from the tools was variable depending on water conditions. These additional tools include:

1. SWP pumping of (b)(2)/ERP upstream releases: Modeling studies indicated that this tool could generate on average about 40,000 acre-feet.
2. EWA use of SWP excess capacity: Modeling studies indicated that this tool could generate on average about 75,000 acre-feet.
3. Export/Inflow ratio flexibility: Modeling studies indicated that this tool could generate on average about 30,000 acre-feet.
4. 500 cfs SWP pumping increase: Modeling studies indicated that this tool could generate on average about 30,000 acre-feet; however, this tool is only useful to transport water purchased north of the Delta to south of the Delta. This tool does not generate new assets.

These four Delta operations tools are less straightforward than water purchases and require some additional explanation. The SWP pumping of upstream releases results in a sharing on a 50:50 basis between EWA and EWP of water meeting several conditions. First, the water was released from storage or otherwise made available for upstream purposes under either CVPIA Section 3406(b)(2) or the ERP and arrives in the Delta with no further (b)(2) or ERP purposes to serve. Second, the release exceeds the capacity of the CVP Tracy pumping plant. Third, the EWA has demand south of the Delta. Finally, the SWP has the capacity to pump the water when it is available.

EWA use of excess SWP capacity actually entails using excess SWP pumping capacity to pump water for both the CVP and the EWA, to be shared between them on a 50:50 basis. The CVP water can be from storage or other Delta water rights to divert unstored water. The EWA water can be from either non-project water acquired north of the Delta, or stored or unstored water pumped under CVP or SWP water rights. This arrangement is also known as "Joint Point". Alternatively, the SWP may use its own Delta diversion rights to pump water from the Delta for EWA purposes when the SWP has capacity but no demand. This alternative is preferable to create assets south of the Delta to offset SWP losses from Delta export curtailments.

The final two tools represent project pumping made possible by relaxation of several regulatory requirements. Permission was obtained from the Army Corps of Engineers to relax the limitations on SWP pumping under Section 10 of the Rivers and Harbors Act. Under the Act the three-day average diversion into Clifton Court Forebay is limited to 13,250 acre-feet per day. This is equivalent to an average, 24-hour pumping rate of 6,680 cfs. The base diversion rate was increased by the equivalent of 500 cfs to 7,125 cfs for July, August, and September, with all the water going to the EWA. The other regulatory relaxation concerns the Export/Inflow ratio. Project exports are limited at different times of the year to a set percentage of Delta inflow, either 35% or 65%. Relaxations of these percentages will be sought as appropriate with the additional exports used to create EWA assets south of the Delta.

In fact, Condition 1 was never been met, although an operational EWA was declared by the MAs and PAs each year (Table 4). The inability to meet Condition 1 was a source of great concern to stakeholders (Swanson 2001, 2002), especially in Year 1, when the lack of full assets may have limited the options of the MAs in taking fish actions or limited actions to reduce winter-run incidental take. The inability to meet condition 1 was formally recognized in 2002, resulting in an agreement that SWP would provide the ability for EWA to borrow up to 100,000 acre feet in any year, to be repaid such that the SWP allocations in that year are not affected or, if the debt is carried over, that allocations that year are not affected. Also, more water was purchased than called for in the ROD, at least partially offsetting the lack of Condition 1 assets.

[Table 4 near here]

Another major concern during the EWA trial period has been the identification of Tier 3 protections and the protocol for using them (Swanson 2001, 2002, EWA Review Panel 2001). Again, in the early years of EWA, the lack of identification of Tier 3 assets and the conditions under which they can be used, was perceived as constraining the ability of the MAs to take all actions needed for the benefit of fishes (Swanson 2001, 2002, EWA Review Panel 2001). The full description of Tier 3 in the ROD is as follows (ROD, pgs. 57-58):

> Tier 3 is based upon the commitment and ability of the CALFED Agencies to make additional water available should it be needed. It is unlikely that assets beyond those in Tier 1 and Tier 2 will be needed to meet ESA requirements. However, if further assets are needed in specific circumstances, the third tier will be provided. In considering the need for Tier 3 assets, the fishery agencies will consider the views of an independent science panel. Although the CALFED Agencies do not anticipate needing access to Tier 3 of water assets, the CALFED Agencies will prepare an implementation strategy for Tier 3 by August 2001, establishing a timely scientific panel process and identifying tools and funding should implementation of Tier 3 prove necessary.

This issue was first addressed with completion of an interim protocol in 2002, with the most recent revision of the Tier 3 protocol occurring in April 2004 (MAs 2004). The Tier 3 protocol contains 6 major provisions:

1. **Tier 3 is not an operational reserve for Tier 2.** The CBDA Agencies agree that Tier 3 actions are separate from EWA and that the EWA should not rely upon the existence of Tier 3 assets in its planning or operations. Tier 3 is a fail-safe device, intended to be used only when Tier 1 and Tier 2 are insufficient to avoid jeopardy to the continued existence of an endangered or threatened species.

2. Tier 3 assets will be used when: (1) EWA assets are exhausted (see Item 3); and (2) the Management Agencies determine that jeopardy due to project operations will occur unless additional measures are taken (see Item 4 below).

3. EWA assets are defined as exhausted when all real assets have been used and the limit on borrowing has been reached. The real assets include (1) the purchased assets that are being acquired for 2004; and (2) any operational assets that have been accrued or can reasonably be acquired in the near future. For 2004, the initial limit on borrowing has been established as 100 TAF. This amount represents the amount of water that could be extracted from groundwater in any single year. Additional borrowing may be developed through the year, but would be on a case-by-case basis.

4. The appropriate Management Agencies will make the determination that a species is near jeopardy if project operations are not modified. The Management Agencies will request and consider the views of an independent science panel. At a minimum, this science panel will consist of the two EWA science advisors who are expected to respond within 48 hours. If sufficient time is available, additional independent scientists may be consulted. The Management Agencies have the discretion to take action while awaiting feedback from the science panel.

5. **Tier 3 assets will be used to the extent available to compensate the Projects and water users for impacts to their water supply from actions taken to avoid jeopardy.** If all Tier 3 assets are used, and additional actions are needed to avoid jeopardy, ESA consultation regarding project operations will be re-initiated. The biological opinion on re-initiation will include reasonable and prudent alternatives necessary to avoid jeopardy. Actions to avoid jeopardy will not be limited by the “no harm” principle (i.e.: there is no commitment that all water supply losses can be fully mitigated).

6. **The State and Federal Projects will be responsible for making preparations for the activation of Tier 3.** DWR and USBR are responsible for making preparations for the activation of Tier 3, just as they are responsible for acquiring EWA assets. Such preparations could include the acquisition or identification of water purchase options that could be converted easily into water. The cost of exercising the options would be paid by the Tier 3 fund. The Project Agencies should work cooperatively with the EWAT and other CBDA-related water purchase programs in developing a Tier 3 purchase plan.

The protocol makes clear that Tier 3 assets are not to be considered in the day-to-day operations of the EWA. In essence it is an insurance policy against extraordinary circumstances. A likely example of such an extraordinary circumstance might be the later years of prolonged drought when populations of fishes are at extremely low levels.

During the first 4 years of EWA several other problems with the tools (Table 5) and assets have been noted besides the failure to receive the Condition 1 assets. First, a court ruling reduced the Tier 1 baseline protections by altering the interpretation of (b)(2) water resulting in less (b)(2) water being available for Delta uses compared to the original 800,000 acre feet. Although, not really a problem with the design of EWA, this change places greater demands on the remaining

EWA assets. Lack of storage capacity south of the Delta has repeatedly been noted as a major constraint on the use of the flexible tools to build assets for future years or to carryover surpluses from one year to the next (e.g., CBDA 2004). Specifically, this refers to the one-time 200,000 acre foot allocation described earlier, which also would have provided storage for water obtained by other means such as the operational tools. Without dedicated storage, EWA assets are the first to spill from San Luis Reservoir (see footnote 3 of Table 5). Also water contractors have senior rights for excess SWP pumping (see footnote 2 of Table 5). This has limited the effectiveness of the tools in building EWA assets (Table 5). Partially in response to these problems, the EWA has focused more on north-of-Delta resources than originally envisioned. North-of-Delta water also tends to be less expensive than south-of-Delta water. North of Delta storage and transfers are also desirable because in-stream benefits are realized if water transfers can be timed with fish needs. Early experience with the tools and assets in the first 4-years was presumably beneficial in determining the balance of assets and tools included in the EIR/EIS for the continuation of EWA, which also includes consideration of increasing water demand and changing water management facilities, both important considerations (Swanson 2001, 2002, EWA Review Panel 2002, 2003).

[Table 5 near here]

Operation of EWA

In principle, the operation of the EWA is straightforward. The PAs provide the assets promised in the ROD and EWA Operating Principles Agreement. The MAs utilize monitoring data, scientific understanding, and professional judgment to determine the actions required to protect and recover Delta fish populations and ecosystem function. The PAs then implement those actions. The MAs are provided a water budget and gain additional water resources (Tier 2) and the flexibility to use EWA assets and tools in whatever manner they believe is best for the resource. The MAs adopt some risk in that suboptimal use of the available assets and tools might result in little or no additional benefit to the resources of concern over that provided by the baseline protections (Tier 1). Conceptually at least, if the benefits do not justify the cost, such failure could result in consideration of investment of the monetary EWA resources elsewhere, such as the habitat restoration goals of the ERP. The PAs gain assurance that they will be able to meet their contractual obligations with water users. This assurance, in principle, simply costs the money necessary to provide the EWA assets and tools; however, considerable effort is necessary to locate willing sellers and to deliver the water when and where it is needed.

The basic assumption that operations of the CVP/SWP pumping facilities have significant but unquantified effects on the fish populations of concern is central to the idea that EWA can contribute to the recovery of those populations. This assumption is discussed further below. If this assumption is not true, the justification for EWA might be reconsidered. This might not necessarily result in cancellation of the program. For example, EWA could be one of the most effective actions that can be taken in the Delta for recovery of fishes, even though the contribution to the recovery of populations is relatively small. Under such circumstances, even a small improvement could be seen as beneficial, especially if it increases water supply reliability for water users.

Although straightforward in principle, the actual operation of EWA is relatively complex and involves several groups (Figure 3). As mentioned earlier, the actual operation of the EWA is focused on Chinook salmon and delta smelt. Each of these is discussed in detail below. The general process is as follows. Fish monitoring data are collected by agency biologists, primarily FWS and DFG. Hydrologic, weather and operation forecasts are provided by the PAs. The field biologists check the data for errors and then disseminate the data via the Internet and conference call to the biologists on the Data Assessment Team (DAT), which focuses on Chinook salmon and delta smelt, or the Delta Smelt Work Group (DSWG), which focuses on delta smelt. The DAT groups include agency biologists, stakeholders, and project operators. The DSWG does not include stakeholders. DSWG comments always pass through the DAT to allow for stakeholder comment. On a weekly basis, these groups synthesize and interpret the available data and determine if any operational changes are necessary to protect fish based on established decision criteria, known as decision trees (the newest iteration for delta smelt is called the delta smelt risk assessment matrix). Another group where stakeholder involvement occurs is the Operations and Fish Forum (OFF). This group (formerly known as the "No Name Group" within local circles) works with the other groups when particularly difficult situations and decisions are expected. If operational changes are deemed necessary, the recommendations are forwarded to the Water Operations Management Team (WOMT) for further discussion and action. The WOMT consists of senior management representatives from the MAs and PAs. The CALFED Operations Group (CALFED OPS) meets monthly and mainly provides a public forum regarding water planning, forecasts of water availability, water transfers, facility operations, and fish issues. On a day-to-day level, most of the activity occurs as communications among the DAT, DSWG, OFF and WOMT. The timeframe of such communication ranges from weekly, when concern for at risk species is low, to daily, when concern is high and operational changes are being considered. As part of the EWA process, many of these communications are documented and summarized for later review of the decision making process, determination of the actual outcomes of decisions, and comparison of expected outcomes with actual outcomes. Two aspects of the EWA operations deserve particular attention, the decision trees that guide EWA actions and the level of staffing support required by the EWA.

In essence, the decision trees represent conceptual models of the movement of a species through the delta and the vulnerability of various life stages to the effects of the CVP/SWP pumps (hereinafter, "pumps"). It is also appropriate to mention here that the pumps are considered to have two classes of effect. Fish can be entrained directly into channels leading to a pumping facility. The effects associated with this process are known as direct effects. Entrained fish can either be "salvaged", when they are bypassed by screening facilities into holding tanks for transport by truck for release back into the Delta, or they can pass through the screens, directly into the diversion canals, where they are lost to the system. Salvaged fish are subjected to several sources of mortality during the screening process. First, there is prescreen mortality, which includes losses to predatory fishes that feed on smaller fishes at the entrance to the screening facilities. At the SWP, this includes losses to predation in Clifton Court Forebay. The magnitude of this loss has been studied for Chinook salmon, using releases of marked fish and subsequent recaptures at the screening facility. Losses in Clifton Court Forebay have been estimated to be 63-99 % for hatchery-reared Chinook salmon (White et al. 2003). Second, considerable mortality of some species can occur as part of the salvage and trucking process. In the case of delta smelt, mortality is estimated at 100%. In the context of the hydrodynamics of the Delta, fish with a high likelihood of being entrained as a function of their proximity to the pumps and the interaction between pumping rates, river flow, and tides are said to be in the "zone of entrainment".

Indirect effects result not from fish being entrained into the pumping plants but from hydrodynamic effects that delay movement of fish through the Delta because of modifications to migration routes or the environmental cues that guide migration. Presumably such delays increase exposure of individuals to any sources of mortality in the Delta. This is usually assumed to be predation, although a variety of other mechanisms have also been hypothesized. Fish with a high probability of experiencing such effects are said to be in the "zone of influence" of the pumps. The purpose of the decision trees is to formalize the conceptual models used in making decisions about operational changes intended to minimize both direct and indirect effects on the species of concern.

The Chinook salmon decision process actually focuses on the "older juvenile" Chinook salmon. In the early part of migration season, the decision process is focused on yearling spring-run Chinook salmon (Fig. 4A). Mill, Deer, and Butte Creek support the largest remaining populations of naturally reproducing spring-run Chinook salmon (DFG 1998 [Status report]). Yearlings are operationally defined as young Chinook salmon > 70 mm fork length between October and April. DFG operates rotary screw traps in the lower reaches of these streams to monitor the emigration of yearling spring-run Chinook salmon and later in the season, spring-run and fall-run Chinook salmon fry. Capture of yearling spring-run Chinook salmon or a 50% increase in average tributary flow are considered evidence of the beginning of the migration season. The flow criterion is included because yearling Chinook salmon are not highly vulnerable to capture by rotary screw traps. The beginning of the migration season, or first alert, begins a heightened level of attention by those involved in the decision process and an "early warning" for closure of the DCC. An increase of flow at Wilkins Slough on the Sacramento River, near Knights Landing and approximately 35 miles upstream of the Delta, has been associated with emigration of juvenile Chinook salmon past Knights Landing. The Wilkins Slough criterion serves as a second alert that decisions regarding closure of the DCC are imminent.

[Figure 4 near here]

The decision to close the DCC is based on several considerations, including fish catch and water quality. Migration is monitored at Knights Landing by means of a rotary screw trap and at Sacramento by means of a midwater trawl towed at the surface. The "catch index" for both (KLCI and SCI, respectively) consists of the catch of older juveniles standardized to one day of effort. If the water quality criteria for salinity are met for predetermined points in the Delta, then closure of the DCC for fish protection is not an issue. However, if the water quality criteria are not met, then closure of the DCC becomes an issue because the closure can cause water quality to worsen in the Central Delta and subsequently at the pumps. Basically, with the DCC closed, Sacramento River water is directed toward Suisun Bay rather than proceeding into the Central Delta and then to the South Delta for export at the pumps. With the DCC closed, continued exports draw saline water from Suisun Bay into the Central and South Delta. In these cases, fish protection and water quality protection needs conflict. If a consensus decision can not be reached by the DAT and OFF, the conflict is elevated to the WOMT for a decision. This situation is most likely to occur from November through January.

A KLCI or SCI of greater than 10 from November through February or greater than 15 from March through April are taken as indicators that a substantial number of older juveniles are entering and present in the Delta and will potentially be exposed to the effects of pumping for several weeks. This situation serves as a third alert, and signals consideration of modifications to export rate. Also considered at this point is an annual FWS Chinook salmon survival experiment, conducted between December and January. The goal of the experiment is to determine the relationship of juvenile Chinook salmon survival with Delta inflow and exports. The experiment is conducted when the following conditions are expected: ten consecutive days of consistent environmental conditions, Delta inflow, and exports; KLCI or SCI greater than 10; and projected Sacramento River flow increased by 20%. Once the experiment is initiated, maintaining the necessary conditions becomes a consideration in the EWA process, although the conduct of this experiment is not an explicit part of EWA.

Once the third alert has been reached and considerable numbers of older Chinook salmon are in the Delta, Chinook salmon loss at the pumps becomes the criterion for export reductions (Figure 4B). There are two measures of loss. The first is based on the loss of wild (non-fin-clipped) older juveniles. The second is based on cumulative loss of late-fall run Chinook salmon released from Coleman fish hatchery, which are in the same size range as older juveniles. It is important to note that the measure of loss for wild fish is a calculated number based on the number of older juveniles salvaged and various assumptions about pre-screen and post-screen mortality. The Coleman criterion assumes that the hatchery released late-fall run fish are similar in behavior and distribution to wild older juveniles.

The fourth alert is reached when the loss density of older juveniles exceeds 8 fish per thousand acre-feet pumped or the cumulative loss of Coleman late-fall run equals or exceeds 0.5% of the number released (Figure 4B). The fifth alert is reached when the loss density of older juveniles exceeds 15 fish per thousand acre-feet pumped. Export reductions are considered whenever alert levels are reached. If sufficient EWA assets are available, exports are reduced. If sufficient assets are not available, recommendations are elevated to the WOMT for a decision. Peak migration of older juveniles is generally over by March, when salvage of delta smelt becomes the major issue.

The original delta smelt decision tree (Figure 5; Nobriga et al. 2001) will be superseded in 2004-2005 by the delta smelt risk assessment matrix (DSRAM) (Figure 6) (USFWS 2004). In some respects the management process for delta smelt is more complex than the Chinook salmon decision process. First, the delta smelt process considers both adult and juvenile life stages. Second, the delta smelt process includes decisions about changes in San Joaquin River flow and South Delta barrier operations in addition to export reductions and closure of the DCC. The South Delta barriers are a group of temporary barriers installed in South Delta channels to maintain water levels for agricultural diversions. These barriers are equipped with tidally operated flap gates. These gates may be allowed to operate normally or the flap gates can be tied open to allow tidal flushing. Another issue surrounding delta smelt management is that reliable population estimates are not available. Management is based on population indices calculated from data collected by a variety of monitoring programs.

[Figure 5 near here]
[Figure 6 near here]

The DSRAM provides monthly criteria, which if exceeded, trigger a meeting of the DSWG. The objective of the DSRAM and DSWG is to provide proactive actions for the protection of delta smelt prior to increased salvage at the pumps. BOR and/or DWR are responsible for monitoring the DSRAM criteria and reporting the results to FWS and DSWG. If criteria are exceeded, BOR and/or DWR inform the DSWG. The DSWG is then responsible for calling a meeting. If a meeting is called, the DSWG decides on recommendations for protection delta smelt and shares those recommendations with DAT and forwards them to WOMT for discussion and potential implementation. If an action is implemented, the DSWG is tasked with an assessment of the effectiveness of the action.

The DSRAM (Figure 6) is less straightforward than the Chinook salmon decision process because it considers more life stages, more possible triggers, and a wider variety of actions. In essence, the DSRAM formalizes the various factors the DSWG considers in reaching a consensus on the status of the delta smelt population and the level of risk to the population given environmental conditions and pumping rates. It is more qualitative than the older juvenile decision tree, which has explicit decision points and criteria (Figure 5). The following is a summarization of information available in (USFWS 2004). The level of concern for delta smelt is heightened under the following circumstances:

1. Low adult population: The adult population is considered low if the Recovery Index is below the median of 74 for the period 1980-2002. The Recovery Index is based on a subset of data collected during the Fall Midwater Trawl Survey conducted by DFG. The level of concern is also heightened when spawning occurs in locations where larvae and juveniles will be subject to entrainment.

2. Spawning near pumps: Spawning tends to occur in the central and south Delta when X2 (the 2 psu isohaline) is located upstream of Chipps Island. Spawning usually begins in March at temperatures between 12C and 18C. Larvae and juveniles continue to be found in the Delta until temperatures reach or exceed 25C.

3. Short spawning period: Spawning usually begins in March but ceases in April or May when water temperatures exceed 18C. In years when the Delta warms rapidly, the time period with appropriate water temperatures is short, resulting in fewer young produced. Based on water temperatures from 1984-2002, starting Feb 1, the 25% quartile for spawning days was 39 days through April 15 and 50 days through May 1.

4. Spawning stage: Ripe delta smelt females (stage $\geq$4) serve as an indicator that spawning is occurring.

5. Distribution (and abundance): The centroid of the juvenile population distribution is calculated from data collected by the DFG 20-mm Survey. Concern is high when the centroid is located upstream of the confluence of the Sacramento and San Joaquin Rivers, placing the bulk of the population in the Delta, where vulnerability to the pumps is higher. Concern is also high when 20-mm Survey juvenile cumulative catch (i.e., abundance) during specific survey periods is less then the median calculate from data for the period from 1995-2003.

6. Salvage triggers: Adult delta smelt move into the Delta to spawn from December through March. The trigger for adult salvage is based on the ratio of adult delta smelt salvage to the fall midwater trawl index. If the value exceeds the median value calculated for December to March, 1980 to 2002, then concern is high. The juvenile salvage trigger is any catch greater than 0 in May or June. May and June are the peak months of delta smelt salvage, and peak salvage is not predictable with the present data. The DSWG expects to meet regularly during this period.

Over the course of the four year trial period for EWA, a total of ?? fish actions were taken. ?? of these actions were for salmonids and ?? were for delta smelt (These figures will be obtained from the MAs when available).

The total time commitment to operation of the EWA is difficult to document because the majority of participants are assigned to EWA on a part-time basis or are not considered part of the official EWA staff. A recent estimate puts direct, funded EWA involvement of the MAs and PAs at about 13 personnel years (or FTE) per year (Table 5) exclusive of top level managers dealing with EWA implementation issues or the time spent by agency biologists not assigned to EWA but participating in workshops, review sessions, and other activities. Of the 13 personnel years only about 5 are involved with the direct fish management aspects of the EWA. The remainder is devoted to administration, water purchasing, contracting, accounting, environmental compliance, and similar activities. Many of the most experienced biologists and project operators involved with the EWA are actually involved as part of their ongoing activities with the IEP and other established research, monitoring, and regulatory programs. The monitoring efforts providing data to DAT, DSWG, and WOMT are completely funded by other programs for other activities and represents a major benefit to the function of EWA at no cost to the program. However, this indirect involvement of many of the most experienced personnel has a negative side. The EWA process is a focus for many during the winter and spring period when fish actions are being taken. For the remainder of the year, many of those involved have other duties to perform and involvement in the EWA process becomes less of a priority. The repercussions of this are discussed further in following sections.

[Table 5 near here]

Criteria for Success of Actions and the Program

In many EWA documents, the EWA is characterized as an experiment. This is true at several levels, which can lead to confusion at times. The EWA is certainly an experiment in management. The EWA requires that the MAs, PAs, and other stakeholders work cooperatively to acquire assets and implement EWA actions. This may be considered as the "administrative success" of the program. The success of this aspect of the program is certainly important but it is fundamentally different from the success of the EWA in meeting its biological goals of fish protection and restoration/recovery. Although this is a relatively trivial issue because all agree that cooperation has been good, I would argue the ROD and OPA **mandate** that the EWA will be a cooperative management program. This puts this goal in a somewhat different context. Failure of the EWA due to a lack of cooperation would have been due to a lack of leadership within and among the MAs and PAs, the major architects of the EWA. I suggest that such a failure of leadership is fundamentally different from the failure of a program to achieve its goals because of a poorly designed decision process or flawed actions.

The success of the EWA at meeting the biological goals can be discussed at various levels including the success of individual actions, the cumulative success of EWA actions over a single year, and, more recently, the comprehensive success of the EWA in the context of all CALFED Programs. It is also worth observing here that the EWA is often identified as an adaptive management program. As observed by the EWA Review Panel (EWA Review Panel 2002), the term adaptive management has been used so widely for such a wide variety of management activities in CALFED and elsewhere that the term has lost much of its original meaning. All are better served by specific reference to program elements and how to assess those elements.

Many EWA documents focus on reduction of fish entrainment as the measure of success of the program. This is an understandable focus because fish salvage (an indicator of entrainment) is a measurable quantity that can be altered by manipulating project operations. However, it needs to be recognized that accepting decreased salvage as the sole measure of success results in a program that cannot fail. Any pumping curtailment when species of concern are present likely reduces the salvage of that species at the pumps by some amount. Also, as recognized by the MAs, this assumes that the population distribution of the species does not change substantially during any curtailment. In other words, an action may have less benefit than assumed if the population distribution of a species shifted away from the pumping facilities concurrent with an action to decrease entrainment.

The MAs have made some progress in estimating the success of individual actions and cumulative actions over the year, at least for Chinook salmon. The best data exist for winter-run Chinook salmon and represents the best case for calculating the benefits of EWA actions. The spawning habitat of winter-run Chinook salmon is limited to the portion of the mainstem Sacramento River, below Keswick Dam, with appropriate spawning habitat and water temperatures. The size of the spawning population is estimated annually with carcass counts. Juvenile production is estimated by catches in RSTs. Finally, the race of juveniles captured can be identified with a high degree of confidence based on genetic testing. These data combined with estimates of direct and indirect mortality in the Delta (based on experiments with hatchery fish) and at the pumping facilities have allowed biologists to estimate the number of winter-run Chinook salmon saved by EWA actions (White et al. 2003), albeit with some unknown but likely high degree of uncertainty. Unfortunately, the quality of data is not as high for the other races of salmon. Their spawning populations are more dispersed. The yearling and older smolts of spring-run Chinook salmon and steelhead are not highly vulnerable to capture. Substantial hatchery supplementation of steelhead and fall-run Chinook salmon populations can complicate interpretation of data. The next level of assessment above that of estimating the number of winter-run salmon saved at the pumps is the population-level significance of those fish. In other words, how many of those fish return as adults and what percentage of the population do they represent?. These estimates require estimates of ocean survival and closure of the life cycle model. Despite the problems, the results with winter-run Chinook salmon are encouraging and continued life cycle model development should be pursued.

The situation with delta smelt is less developed primarily because the species is difficult to sample, there is no accepted methodology for estimating population size, and many aspects of the life cycle are still poorly understood or unknown. Despite these problems, substantial progress is being made in understanding delta smelt ecology (Bennett 2004). However, this increasing understanding has not progressed to the point where estimates of number of fish saved are practical. Success of delta smelt actions are still largely restricted to avoiding levels of salvage that result in regulatory action under the Biological Opinion. The most recent EWA delta smelt workshop focused on new and ongoing attempts to model the delta smelt population (Kimmerer and Brown 2003). The results of the workshop were encouraging and suggest that more quantitative descriptions of delta smelt population biology may be forthcoming.

The previous discussion has mainly addressed the assessment of the results of individual fish actions or the cumulative effects of fish actions over a single season. As the first four years of EWA ends, many stakeholders are interested in a more comprehensive assessment of the EWA. Such a comprehensive assessment not only includes the biological outcomes of EWA actions but an evaluation of the success of the EWA in relation to the other CALFED Programs. Many of the problems and issues related to a comprehensive evaluation of the EWA have been addressed by Hymanson et al. (2003) in a report to the EWA Review Panel. The following discussion depends heavily on Hymanson et al. (2003); however, that report was only a first step in designing a comprehensive assessment of the EWA.

Hymanson et al. (2003) make a distinction between performance standards and evaluation criteria (Figure 7). They relate performance standards to the goals of the EWA. Those performance standards are:

1. Protection of fish in the estuary
2. No uncompensated water costs to project users, and
3. Implementation as a cooperative management program

Hymanson et al. (2003) also recognize a fourth performance standard:

4. Success, in combination with other CALFED programs, in achieving CALFED's fishery protection and restoration recovery needs.

They present this standard separately because the EWA is not expected to meet this CALFED goal alone but in concert with the ERP actions and regulatory baseline requirements. This interpretation of goals is similar to that presented earlier in this report, except for the inclusion of implementation as a cooperative management program, requiring a minor modification of their evaluation framework (Figure 8). As mentioned earlier, cooperation is an important aspect of the EWA but should not be a major consideration in determining the succes of the EWA in meeting its goals.

[Figure 7 near here]
[Figure 8 near here]

Hymanson et al. (2003) suggest a process for comprehensive evaluation of the EWA and a variety of evaluation criteria to determine program performance. They mention three types of criteria. The first evaluates specific actions. The second evaluates specific responses. The third evaluates system or population-level responses. Although Hymanson et al. (2003) acknowledge that many people consider the evaluation of system and population-level responses the ultimate goal, they appear to agree with the perception of the MAs and PAs that it is difficult to separate the effects of a program like the EWA from the effects of other CALFED Programs and actions (e.g., habitat restoration), from processes occurring in other parts of a species habitat (e.g., salmon harvest rates), or from large-scale processes affecting the entire system (e.g., climate change). It also seems likely there will be interactions between CALFED Programs that might affect implementation and success of the EWA (CBDA 2003, EWA Review Panel 2001, 2002, 2003). Their conclusion is that it seems reasonable to expect that an evaluation of system and population-level responses might not occur every year, particularly in the early years. This implies that the tools exist or can be developed to recognize, understand, and isolate the various processes affecting system and population-level responses. This assumption is discussed more fully below.

Hymanson et al. (2003) present a number of ideas for specific evaluation criteria; however, more useful is a ten-step outline of the general steps for an annual comprehensive review:

1. Complete a detailed comparison of annual water operations with and without EWA (EWA versus regulatory baseline).
2. Assess the ability to meet regulatory requirements and preserve water supply reliability.
3. Assess changes in cohort/life stage survival of species of concern.
4. Assess changes in spawning population size of fish species of special concern.
5. Assess changes in environmental water quality in the Delta and upstream.
6. Assess agency interactions/system management (i.e., interagency cooperation and willingness to manipulate the system for EWA or research purposes).
7. Assess EWA economics (i.e, funding, asset management, cost/benefit compared to other actions).
8. Assess program stability/sustainability (i.e., institutional acceptance, changes in management issues, balance of operational and capital expenses)
9. Assess program resilience (i.e., ability to respond to extreme events).
10. Assess collateral benefits/impacts (e.g, increased acceptance of other new tools or changes in water market).

Hymanson et al. (2003) suggest some key steps in the less-frequent evaluation of the broader role of EWA to contribute to CALFED fish protection and restoration/recovery needs, in concert with ERP and the regulatory baseline. Those steps, of equal priority, include:

1. Multi-year comparison of water operations with and without EWA.
2. Re-analyze results of annual evaluations in the context of multi-year trends.
3. Evaluate hypothesized biological cost vs. benefit relative to other actions (e.g., improving delta habitat quality vs. reducing direct mortality).
4. Evaluate the effects of changes in habitat quality.
5. Examine the role of the EWA in listed species status reviews.

An interesting feature of the comprehensive assessment is that it suggests going far beyond a conceptually straightforward assessment of the biological outcomes of EWA actions or even the cumulative effects of other actions. The comprehensive assessment approach incorporates economic and sociological aspects as well. These are certainly legitimate concerns but require expertise far removed from that already involved in the EWA and further, likely would increase the duties of existing staff, whether EWA or otherwise. Assessing the performance of the EWA in comparison with the performance of the actions of other CALFED programs, particularly ERP, implies that similar assessments will be ongoing within the other programs. It is unclear if such similar assessments are ongoing or not and, if not, the identities of the personnel expected to do them are unknown. It seems likely that the same core of locally experienced biologists would be expected to contribute to both efforts.

Another interesting feature of the comprehensive assessment (Hymanson et al. 2003) is that it implicitly recognizes interactions between CALFED programs, interactions shown explicitly in Figure 8. Specifically, there is recognition that EWA actions for fish may have implications for water quality, particularly salinity, bromide, and organic carbon, as well as, water supply reliability. Expanding on this connection, restoration of tidal wetlands as part of ERP may have implications for the form and quantity of organic carbon in the Delta that may affect drinking water quality (Brown 2003). Conceivably, this could affect the reliability of the Delta as a drinking water supply. If additional storage facilities are built and EWA allocated storage, the timing and quantity of pumping and other tools used to fill the storage may need to be considered in light of the effects of the pumping and water transfer activities on the ecosystem. The hydrographs and temperature regimes of many of the rivers in the Central Valley have already been substantially altered as a result of water management activities and those changes have been associated with effects on resident fish communities (e.g., Marchetti and Moyle 2001, Brown and Ford 2002, May and Brown 2002, Seesholtz et al. 2004). More intense water management activities as part of EWA or other CALFED programs are likely to have further effects on the ecosystem.

In summary, the ability to assess the most direct benefit, reduced salvage, of an EWA action for a single species is limited, even for the best known population. However, continued research in concert with developing quantitative life cycle models hold promise for better estimates of EWA effectiveness. In the short-term it seems unlikely that the contributions of EWA to population or ecosystem restoration/recovery can be determined relative to other CALFED Programs, particularly ERP. First, it is unclear whether ERP and other activities are being assessed as to their contribution to restoration/recovery in a way that can be compared with EWA (i.e., measured in a common currency). Second, all CALFED actions take place in the context of substantial natural variability. This makes it extremely difficult to isolate the effect of any single change to the environment. This should not be particularly discouraging. In many respects researchers and managers are examining the opposite side of the coin that has been examined for the last several decades in the San Francisco Estuary, the reasons for declines in fish populations and ecosystem productivity. Many of those issues are now better if not fully understood (see Brown 2003a,b, Kimmerer 2004, Moyle 2002, Bennett and Moyle 1996 for some recent reviews).

Scientific Organization of the EWA

The scientific organization of the EWA was not well defined in either the ROD or the Operating Principles Agreement. Presumably, this was because the EWA has been originally conceived as an innovative management program and mainly required definitions of the tools and assets available with science in the broad sense mainly serving a support function through monitoring, analysis, interpretation and research. There were roles envisioned for the CALFED Lead Scientist and a review panel but those roles were not described in detail.

The present organization of EWA science at the upper levels was the result of conversations between the CALFED Lead Scientist at the time, Sam Luoma, and various upper level managers of the MAs and PAs (S. Luoma, e-mail communication, 11 August 2004). The original function of the Lead Scientist was an arbitor, especially with regard to making a Tier 3 decision if necessary. However, the MAs have the ultimate legal authority and responsibility to act in such cases. The role of the review panel was not well defined other than to provide outside peer-review of the scientific basis and performance of the EWA.

The structure that emerged from the conversations of the Lead Scientist with the management agencies resulted in a much closer working relationship between the CALFED Science Program and EWA than likely was originally envisioned (Figure 9). In this organizational scheme the Lead Scientist appoints 2 academic advisors (EWA advisors) to represent the Lead Scientist. The EWA advisors are to be familiar with the day-to-day workings of the EWA, work closely with the MAs and PAs, and keep the Lead Scientist apprised of developing issues, especially during the winter and spring when fish actions are likely and a Tier 3 decision might be necessary. In this context, the Lead Scientist advises the MAs and PAs regarding the various scientific uncertainties associated with the identification of a Tier 3 situation and any Tier 3 management actions suggested to address the problem.

[Figure 9 near here]

The EWA advisors also serve a “bridge function” facilitating communication among CALFED Science Program staff, academic scientists, agency scientists, agency managers, and stakeholders. This latter function is largely accomplished through annual workshops organized by the EWA advisors and Science Program staff on the EWA with regard to salmonids (Brown and Kimmerer 2001a, 2002a, 2003) and delta smelt (2001b, 2002b, Kimmerer and Brown 2003).

These workshops facilitate the exchange of information and kept all parties informed about the state of knowledge from both the academic and management perspectives. These workshops also helped promote the timely analysis and dissemination of data and interpretations.

The science structure has continued to evolve in response to circumstances. For example, the Science Advisors have not participate in the WOMT to the extent expected and the Science Advisors and Science Program staff assumed additional duties when the Lead Scientist left the program and a replacement was recruited. Similar shifts in structure and responsibility will likely continue as needs and circumstances change.

Superimposed on this rather general science structure is the annual review process. The annual EWA review process, perhaps more than anything else, has emphasized the scientific strengths, needs, and shortcomings of the EWA. The EWA Review Panel includes an impressive collection of world-class experts (Table 7) with a wide array of expertise. Preparations for the annual review and responses to the review have come to dominate the conduct of EWA science (Figure 10). The need to prepare for the review panel annually has led to an emphasis on timely written documentation of EWA actions, results of actions, and the scientific underpinnings of EWA actions. This emphasis on documentation is commendable and has resulted in a wide array of informative, well-written reports. Efforts should be continued to post these reports on the CALFED website in a timely manner. Many of the documents reviewed for this report were not generally available at the time the review began but were posted subsequently. Publication of some of this material in the peer-reviewed primary literature is also desirable but seems largely impractical for many scientists (agency and otherwise) because of limited staff time or funding.

[Table 7 near here]
[Figure 10 near here]

Science Issues in EWA: Identification and Response

The Review Panel has presented a very balance view of the EWA, providing observations on both positive and negative aspects of program performance. The Review Panel has been especially useful in identifying scientific weaknesses in the program, focusing EWA scientists and others on the highest priority issues to improve the scientific underpinnings and ultimately the performance of the EWA. In fact, I was hard-pressed to identify scientific issues that the Review Panel had not already identified (see Table 8 for a partial compilation) in their reports (EWA Review Panel, 2001, 2002, 2003) or that EWA participants had not identified in the preparatory material given to the Review Panel.

[Table 8 near here]

The major weakness of the Review Panel process at present seems to be the lack of an explicit mechanism for addressing the major science issues identified by the EWA panel. At present there seems to be an indirect approach. Agency scientists working on EWA issues are assigned to respond to many of the issues; however, existing staff has minimal time and sometimes lack the expertise to address particular questions. Academic and other non-agency scientists sometimes have or obtain funding to address questions directly or indirectly related to EWA issues but there does not appear to be a dedicated source of funding within EWA to fund non-agency scientists to work on EWA issues. Review Panel recommendations have been addressed to some extent in various reports back to the Review Panel (Table 8). In 2002, the Lead Scientist submitted a response to the Panel Review outlining ways in which EWA and the CALFED Science Program have responded to the panel's recommendations and many of the problems that limit the ability of the EWA staff to respond to the Panels recommendations (Table 8). White et al. (2003) provide a list of responses to comments regarding Chinook salmon (Table 8). Neither the list of recommendations or responses should be considered complete because both recommendations and responses are sometimes hard to distill from the various reports. Of the 47 observations, action items, and recommendations I compiled, about 30 have been addressed in some way. Few have been fully addressed (Table 8).

There does not appear to be any major problem in identifying the scientific issues that challenge EWA. The annual review process does an admirable job of that, resulting in a long list of issues that need to be addressed to establish a strong scientific basis for the operation of the EWA (EWA Review Panel 2001, 2002, 2003). In addition, the CALFED Science Program, MAs, and PAs are straightforward in acknowledging the importance of the issues and have made considerable efforts to address the issues identified by the review panel (Luoma 2002, White et al. 2002, 2003). However, the responses are not comprehensive and, in many instances, seem inadequate given the importance of the issues to the program. There appear to be several major factors contributing to the mismatch between issue identification and response.

First, the EWA was designed and funded for implementation only, primarily securing and using water assets. That is, money is primarily allocated for the acquisition of the EWA assets and the personnel to make the acquisitions and administer them. The EWA does fund a small number of staff (Table 5) but largely relies on scientists funded from other sources for scientific support. No money is earmarked for EWA science activities. Leadership for EWA Science, by design or default, has fallen to the CALFED Science Program. The Science Program staff, and particularly the EWA Science Advisors, has done an admirable job of facilitating science efforts for EWA. However, as noted by the Review Panel (Review Panel 2001), at present there is no formal mechanism that allows or requires the EWA Program to act on, or respond to, critical findings by the Science Advisors (or any other non-EWA entity), In addition, the CALFED Science Program is responsible for the science needs of the entire CALFED Program. The Science Program staff is dedicated but small, including the Lead Scientist, a deputy director, 11 permanent staff, and 7 associate staff (including the EWA Advisors). Because the Science Program is responsible for all aspects of CALFED Science there are few if any mechanisms for dedicating resources specifically to EWA science needs. The upcoming Science Program PSP (proposal solicitation package) will include several topics important to the EWA but there is no guarantee that proposals will be submitted on those topics, that proposals on those topics will survive the review and approval process, or that other proposals with higher priority will not exhaust the available funding.

Second, and related to the first, the agency biologists that work on EWA issues do not appear to have sufficient time available to address all the science-related EWA issues. This is likely especially true for the agency biologists with duties and responsibilities for other programs within and outside of CALFED. Non-agency scientists have similar challenges. Their work is often done under contract or proposal grants with no explicit funding identified for participation in activities such as EWA. Although such collaboration is often forthcoming, such participation has to be limited so that contractual obligations can be fulfilled. This phenomenon of a small group of regional experts being asked to meet a broadening requirement for services is certainly not unique to the EWA or CALFED, but it does invoke real constraints on the ability to address critical science needs in a timely and effective manner. Limits on the expertise of regional experts participating in EWA and CALFED activities further constrain the response. The Review Panel has suggested the hiring of outside experts, post-docs, and students as a way to circumvent some of these restrictions and the Panel has expressed genuine puzzlement regarding the failure to use such mechanisms (Review Panel 2003). It is unclear whether the failure to utilize such mechanisms is due to administrative constraints, funding constraints, simply a lack of interest on the part of potential participants, or a combination of these. A small grant program is supported by CALFED Science Program in collaboration with Sea Grant but that program is CALFED-wide and not focused on EWA science issues.

Conclusion

The first four years of EWA has general been viewed as a "success" in that the program has functioned successfully as a multi-agency collaboration, conflicts between stakeholders have been reduced, and fish have been saved through reductions in salvage. The quantity and quality of work accomplished by all involved in the EWA, from agency staff to the Review Panel, is impressive. However, without some fundamental changes in staffing and/or funding it seems unlikely that an extended EWA will have any improved success at establishing a rigorous scientific basis for population-level or ecosystem benefits. Recent progress has mainly been accomplished by funding and studies not specifically targeted at EWA. There is no guarantee that such research will continue or remained focused on topics relevant to EWA. At present, the EWA is assessed primarily on the basis of salvage at the pumps. As noted by the Review Panel, restricting the assessment of the EWA to this narrow scope may eventually be explicitly made as a matter of policy. However, it seems unlikely that such a decision would be acceptable to stakeholder groups interested in cost-effectiveness or ecological-effectiveness of CALFED actions. This problem is not restricted to the EWA but is true throughout the programs in CALFED concerned with ecosystem recovery. As of yet, there is not a comprehensive monitoring, assessment, and research program in place that would support an analysis of the relative costs and benefits of any particular set of actions. The Science Program is the "responsible" program in this case but will likely act primarily as a coordinator for interaction among programs unless there are major shifts in funding and staffing within CALFED.

Acknowledgements

The CALFED Science Program provided funding for this review. I thank Jim White, Victoria Poage, Randy Brown, Wim Kimmerer, Zachary Hymanson, and Sam Luoma for providing documents and other information. Zachary Hymanson, Victoria Poage, and David Fullerton provided useful comments on an early version of the manuscript.

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Table 1. Species of concern in the Sacramento-San Joaquin Delta listed or proposed for listing under State and Federal endangered species acts (from Brown and Kimmerer 2001a, Moyle 2002).

Common name	Scientific name	Federal status [1]	State status [2]
Chinook salmon	*Oncorhynchus tshawytscha*		
Winter run		E	E
Spring run		T	T
Fall and late fall run		C	--
Steelhead rainbow trout	*Oncorhynchus mykiss* [3]	T	T
Delta smelt	*Hypomesus transpacificus*	T	T
Sacramento splittail	*Pogonichthys macrolepidotus*	DL	SSC
Green sturgeon	*Acipenser medirostris*	NW	--
Longfin smelt	*Spirinchus thaleichthys*	NW	SSC
Pacific lamprey	*Lampetra tridentata*	ND	--
River lamprey	*Lampetra ayersii*	ND	--

[1] E, endangered; T, threatened; C, candidate; NW, species was proposed for listing but listing was found to be not warranted; DL, delisted; ND, petition has been submitted but no decision.

[2] E, endangered; T, threatened; C, candidate; SSC, species of special concern; --, no special status.

[3] Central Valley ESU

Table 2. Fish species collected at Skinner Fish Facility, 1979–1993[a]

Common name	Scientific name	Introduced (I) or Native (N)
Chinook salmon	*Oncorhynchus tshawytscha*	N
Steelhead rainbow trout	*Oncorhynchus mykiss*	N
Striped bass	*Morone saxatilis*	I
White catfish	*Ameiurus catus*	I
Brown bullhead	*Ameiurus nebulosus*	I
Yellow bullhead	*Ameiurus natalis*	I
Black bullhead	*Ameiurus melas*	I
Channel catfish	*Ictalurus punctatus*	I
Blue catfish	*Ictalurus furcatus*	I
Black crappie	*Pomoxis nigromaculatus*	I
White crappie	*Pomoxis annularis*	I
Green sunfish	*Lepomis cyanellus*	I
Bluegill	*Lepomis macrochirus*	I
Largemouth bass	*Micropterus salmoides*	I
Smallmouth bass	*Micropterus dolomieu*	I
Warmouth	*Lepomis gulosus*	I
Redear sunfish	*Lepomis microlophus*	N
Tule perch	*Hysterocarpus traski*	N
Sacramento perch	*Archoplites interruptus*	N
American shad	*Alosa sapidissima*	I
Threadfin shad	*Dorosoma petenense*	I
Splittail	*Pogonichthys macrolepidotus*	N
Sacramento squawfish	*Ptychocheilus grandis*	N
Hardhead	*Mylopharodon conocephalus*	N
Golden shiner	*Notemigonus crysoleucas*	I
Carp	*Cyprinus carpio*	I
Hitch	*Lavinia exilicauda*	N
Sacramento blackfish	*Orthodon microlepidotus*	N
Goldfish	*Carassius auratus*	I
Sacramento sucker	*Catostomus occidentalis*	N
Threespine stickleback	*Gasterosteus aculaetus*	N
Longfin smelt	*Spirinchus thaleichthys*	N
Delta smelt	*Hypomesus transpacificus*	N
Wakasagi [b]	*Hypomesus nipponensis*	I
White sturgeon	*Acipenser transmontanus*	N
Green sturgeon	*Acipenser medirostris*	N
Inland silverside [c]	*Menidia beryllina*	I
Yellowfin goby	*Acanthogobius flavimanus*	I
Chameleon gobyd	*Tridentiger trigonocephalus*	I
Prickly sculpin	*Cottus asper*	N
Staghorn sculpin	*Leptocottus armatus*	N
Riffle sculpin	*Cottus gulosus*	N
Bigscale logperch	*Percina macrolepida*	I
Starry flounder	*Platichthys stellatus*	N
Lamprey	Various Species	N
Mosquitofish	*Gambusia affinis*	I
Pacific herring	*Clupea pallasii*	N

[a] Source: Brown and others 1996.
[b] Identified by Johnson Wang. Electrophoretic confirmation pending.
[c] Also called Mississippi silverside.
[d] According to Scott Matern, UC Davis, two species are actually present: *T. trigonocephalus and T. bifasciatus*.

Table 3. Months when vulnerable lifestages [1] of species of concern may be present in the Sacramento-San Joaquin Delta (from Brown and Kimmerer 2001a, Moyle 2002).

	Month											
Common name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook salmon												
Winter run	S	S	S									
Spring run [2]	S, F	S, F	S, F									
Fall and late fall run	F	F	F	S	S	S						
Late fall run												
Steelhead rainbow trout	S	S	S	S	S							S
Delta smelt	A	A	A, J	A, J	A, J	J	J					A
Sacramento splittail				J	J	J	J	J				

[1] F, fry; S, smolt; J, juvenile; A, adult
[2] These time periods are approximate for all fishes, but the life cycle of spring-run Chinook salmon is particularly complex. Smolts represent yearling fish emigrating as smolts. Fry represent young-of-year fish emigration the same year of adult spawning.

Table 4. EWA assets from ROD and the first three years of EWA operations (modified from CBDA 2004).

	2001	**2002**	**2003**
ASSETS	**(TAF)**	**(TAF)**	**(TAF)**
ROD: One-time 200 TAF stored water equivalent	0	0	0
- PURCHASED ASSETS			
Upstream of the Delta (ROD: 35+ TAF)			
State	105	135	70
Federal	0	7	0
Water Costs			
Carriage and Conveyance	-17	-27	0
Other	0	- 3	0
South of the Delta (ROD: 150 TAF)			
State	159	37	145
Federal	72	61	0
SUBTOTAL	320	209	215
- OPERATIONAL ASSETS			
Gains	48	83	91
Losses		-20 [1]	-16 [2]
TOTAL PURCHASED & OPERATIONAL ASSETS	367	272	290
- CARRYOVER FROM THE PREVIOUS YEAR		77	58
TOTAL ASSETS AVAILABLE IN WY	367	349	348
FISH ACTIONS			
- EXPORT REDUCTIONS			
State	290	215 [3]	322
Federal		72	26
SUBTOTAL	290	287	348
- INSTREAM HABITAT		5	
TOTAL OF ACTIONS	290	291	348
CARRYOVER TO:			
- 2002	77		
- 2003		58	
- 2004			0
SOURCE SHIFT ACTIVATION	50 of 100	0 of 100	0 of 100

[1] A 2:1 Exchange Program between the SWC and EWA occurred between 3/30/02 and 4/8/02 at a cost of 20 TAF. About 20 TAF of EWA water was preserved for later use when otherwise all of the 40 TAF of EWA water would have been displaced from San Luis Reservoir with a concurrent pumping curtailment.

[2] The SWP was able to “back” water for the EWA from San Luis Reservoir into what was assumed to be more secure storage in Lake Oroville between 9/14/02 and 10/6/02. Unfortunately, this water later spilled during flood control operations. SOD equivalent = 16 TAF (accounting for carriage water costs).

[3] A 38 TAF export reduction occurred in March 2002 when this amount of water stored in San Luis Reservoir converted to SWP project water. San Luis Reservoir was full and continuation of planned SWP pumping would have displaced the EWA water. No specific need for a fish action was apparent at the time and no recommendation for a pumping curtailment had been made by the Management Agencies.

Table 5. EWA operational assets from ROD compared to actual benefits during the first three years of EWA operations (modified from CBDA 2004).

Operational Asset	CALFED ROD (average in TAF)	2001 Actual (TAF)	2002 Actual (TAF)	2003 Actual (TAF)
Half of (b)(2)/ERP releases pumped by SWP in the Delta	40	46	3	19
Variation of E/I ratio	30	2	79	67
500 cfs dedicated capacity at SWP Banks pumping plant	(50) [1] (Capacity only)	0 (Capacity only)	0 (Capacity only)	0 (Capacity only)
Joint Point of diversion (the use of excess capacity at SWP Banks pumping plant	75 [2] (pumping excess water in Delta)	0 (pumping excess water in Delta)	0 (pumping excess water in Delta)	0 (pumping excess water in Delta)
ROD Total	195			
Total expected on average and actual total in 2001-2003	145	48	82 [3]	86

[1] Capacity: represents a quantity expected to be moved using dedicated 500 cfs at Banks from the summer-time capability above the 6,680 cfs that is provided in the COE permit, which is valid through the 2004 transfer season. This tool is used to transfer water purchased upstream of the Delta and, unlike the other tools, does not constitute an additional source of water for the EWA except possibly under the very wettest Delta conditions with high Delta flows in the summer.
[2] Capacity: represents one-half of the available excess capacity at the SWP Banks pumping plant. Under balanced conditions, this tool provides only pumping capacity and the EWA must supply water it has either purchased or stored upstream to take advantage of this EWA tool. In normal and wet years, if SWP Article 21 demand is satisfied, this tool can result in the EWA being able to obtain Delta water during excess conditions provided that EWA has either an existing debt in San Luis Reservoir to repay or a location other than San Luis Reservoir, where it can be stored.
[3] Only 20 TAF was retained past the high point in San Luis Reservoir storage and was available for later fish actions.

Table 6. Estimates of EWA staffing levels for project and management agencies (J. White, CDFG, e-mail communication). State agencies are in personnel years and federal agencies in full time equivalents.

Agency	Full-time personnel	Part-time personnel
California Department of Water Resources	5.00	0.75
California Department of Fish and Game	1.00	0.50
U.S. Bureau of Reclamation	1.00	2.00
U.S. Fish and Wildlife Service	1.00	1.00
NOAA Fisheries	0	0.33
Department of Interior Solicitor's Office	0	0.50

Table 7. Members of the EWA Review Panel.

Name	Affiliation	Expertise	Years participated
James Anderson	School of Fisheries, University of Washington	Modeling of salmonid fisheries and ecosystems	2001, 2002, 2003
Ed Chesney	Louisiana Universities Marine Consortium	Fisheries and fish ecology	2001, 2002, 2003
James Cloern	Water Resources Discipline, U.S. Geological Survey	Aquatic ecology, particularly Bay-Delta	2001, 2002
James Cowan Jr.	Dept. of Oceanography and Coastal Sciences/Coastal Fisheries Institute, Louisiana State University	Marine and estuarine fishes	2001, 2002, 2003
Holly Doreamus	School of Law, University of California, Davis	Endangered species act and listings	2001, 2003
Don Erman	Emeritus, Dept. of Fisheries, Wildlife, and Conservation Biology, University of California, Davis	Freshwater ecosystems and policy level ecosystem studies	2001, 2002, 2003
David Freyberg	Dept. of Civil and Environmental Engineering, Stanford University	Hydrogeologist, natural and human history of the Delta	2001, 2002, 2003
Helen Ingram	Dept. of Politics and Society, University of California, Irvine	Institutional change, particularly the Bay-Delta	2001, 2002, 2003
Stephen Monismith	Dept. of Civil and Environmental Engineering, Stanford University	Hydrodynamic modeling, particularly the Bay-Delta	2001, 2002, 2003
Pete Rhoads	Retired, Metropolitan Water District	Development of CALFED ROD and general knowledge of CALFED	2001, 2002, 2003
Kenneth A. Rose	Dept. of Oceanography and Coastal Sciences/Coastal Fisheries Institute, Louisiana State University	Modeling of aquatic populations, communities, food webs, and ecosystems	2001, 2002, 2003
K.T. Shum	Contra Costa Water District	Water quality and knowledge of Bay-Delta water issues	2001
Barton (Buzz) Thompson Jr.	School of Law, Stanford University	Natural law, environmental resources, water resources, and property	2001, 2002, 2003

Table 8. see separate landscape table.

Figure 1. The Sacramento-San Joaquin Delta.

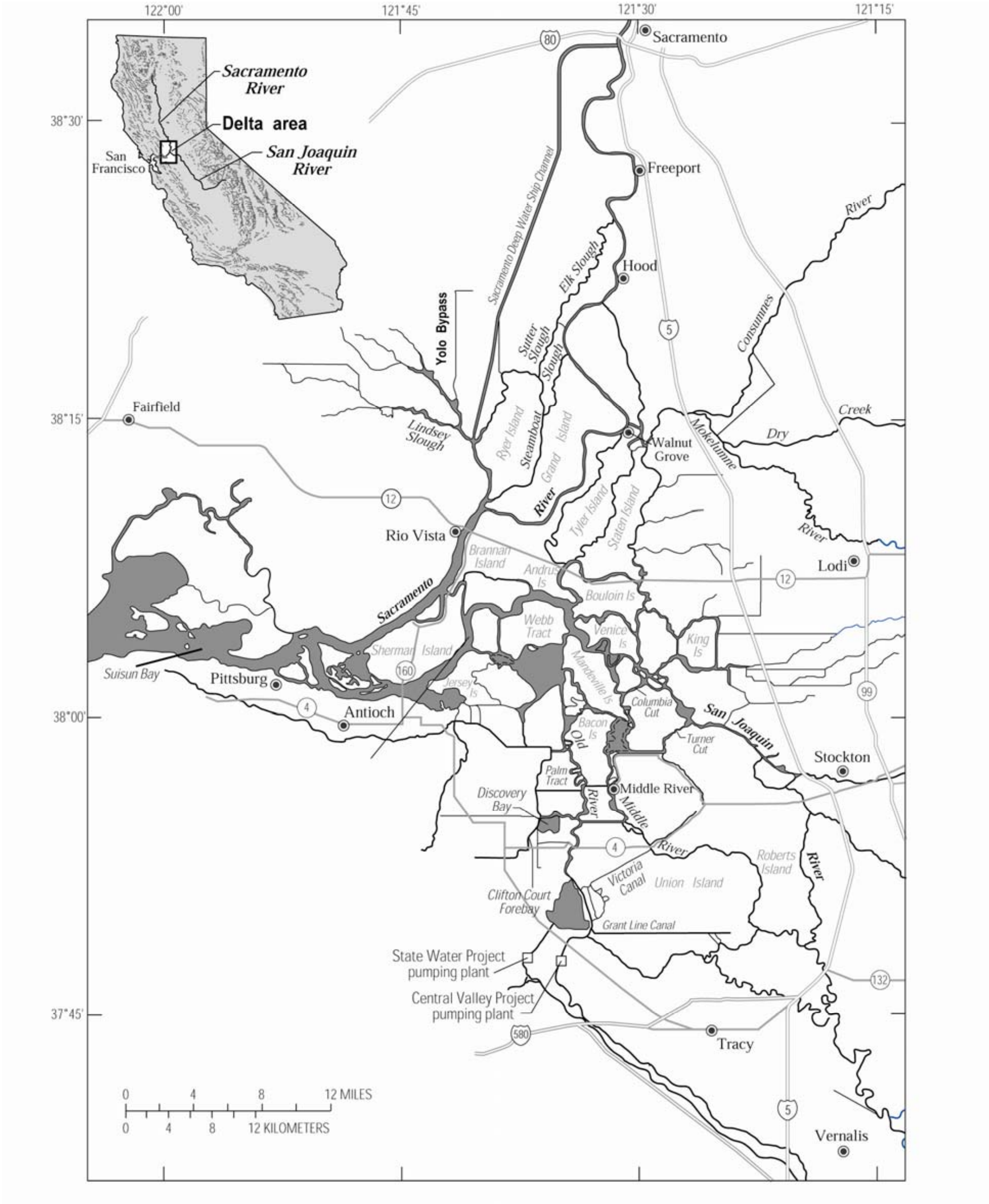
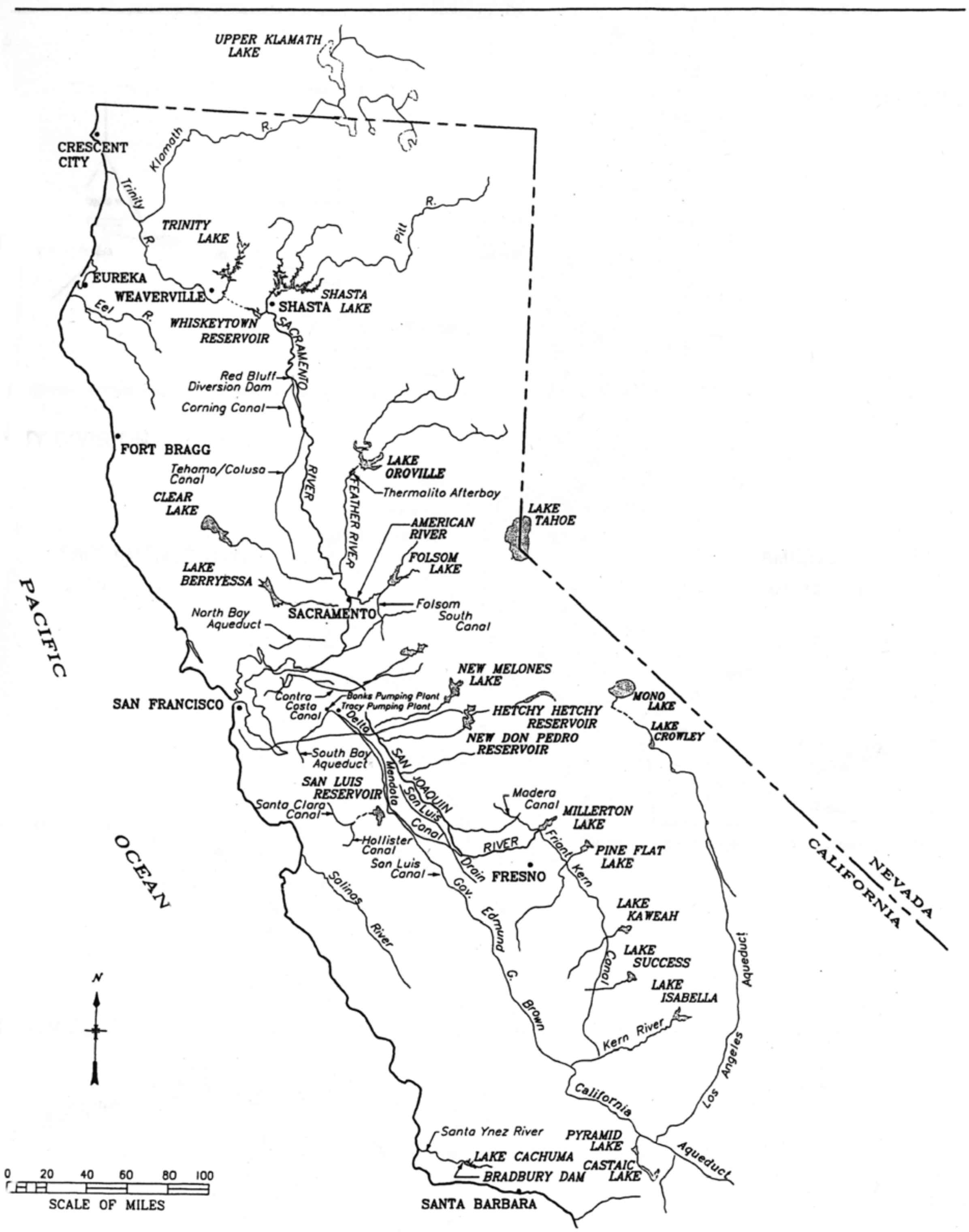


Figure 2. The San Francisco Estuary watershed.



Major features of the Central Valley Project and the State Water Project

Figure 3. The EWA decision process. Stakeholder participation is indicated by asterisks.

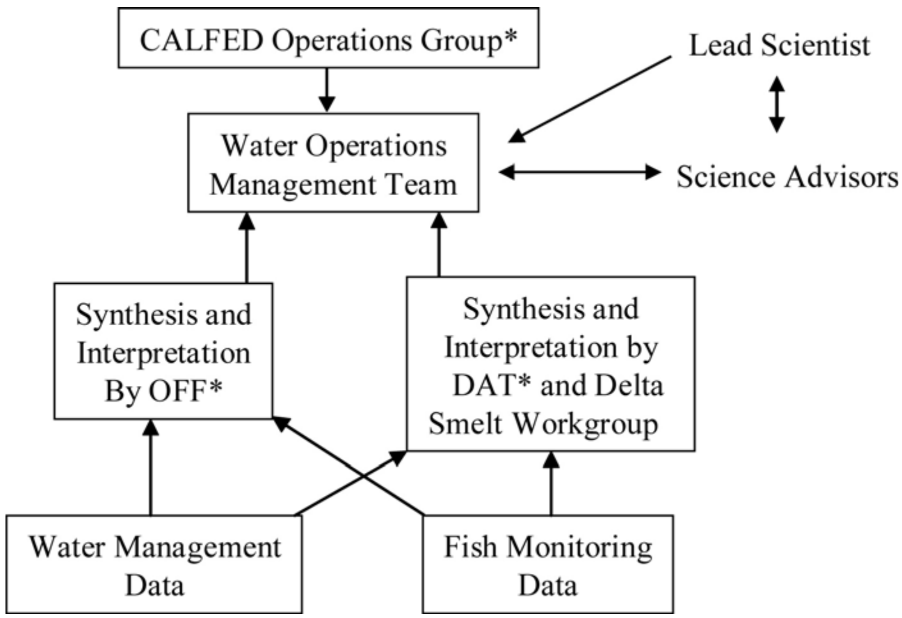
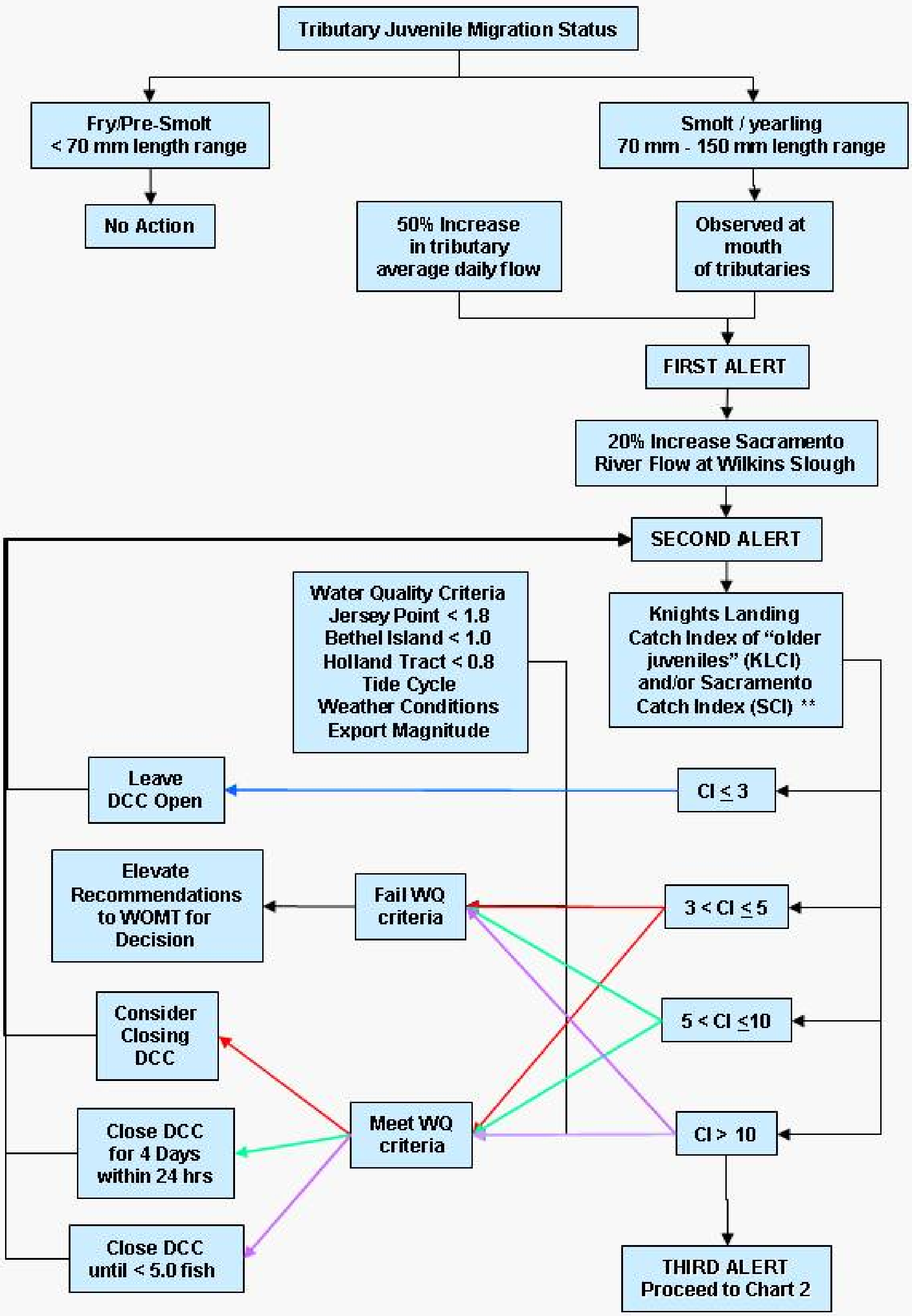
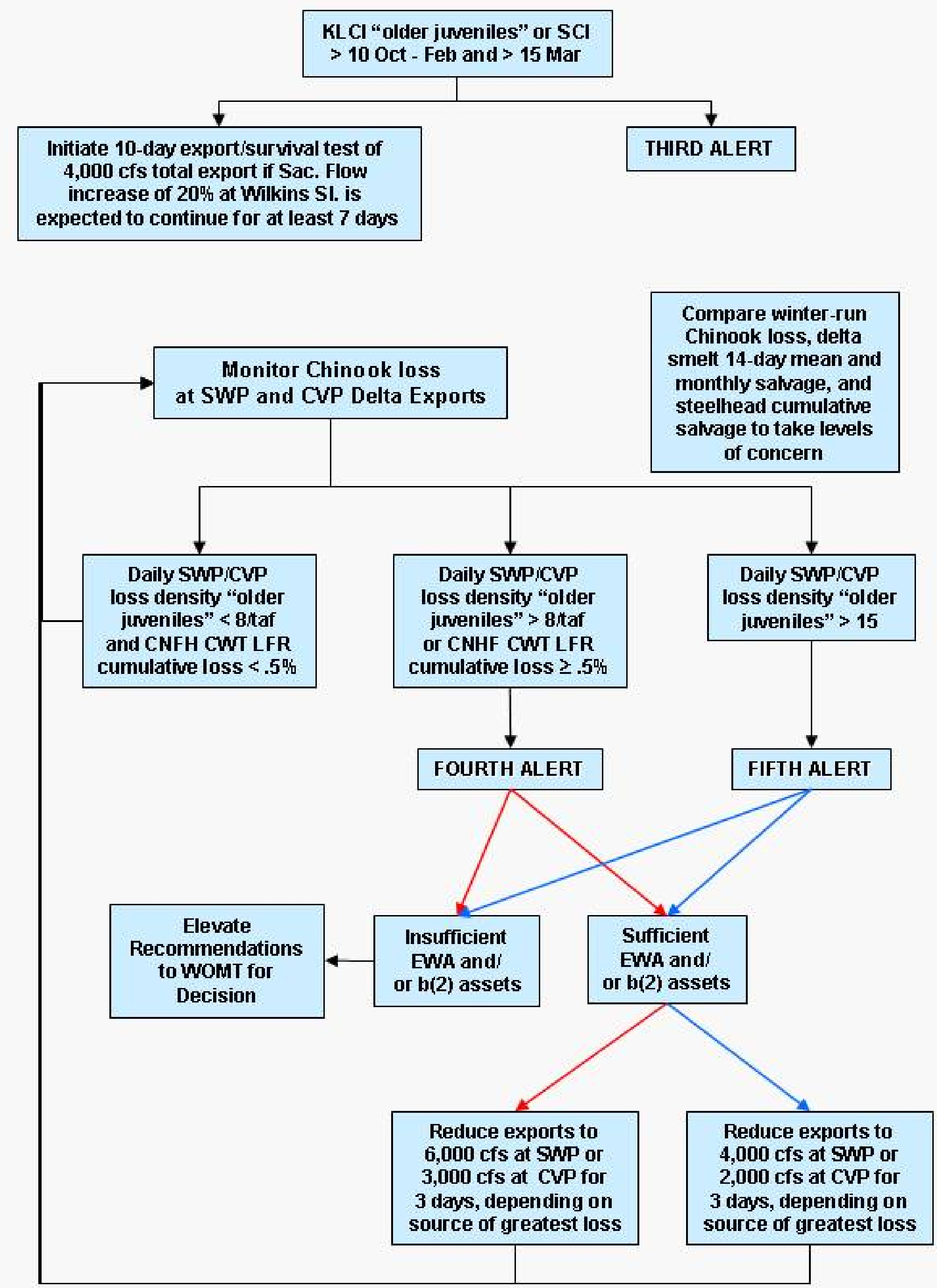


Figure 4A. The salmon decision making process up to the third alert as of 2003.



2002/2003 Chinook decision process October through March (Chart 1 of 2).

Figure 4B. The salmon decision making process after the third alert as of 2003.



2002/2003 Chinook decision process October through March (Chart 2 of 2).

Figure 5. The Delta Smelt Decision Tree, slightly modified from USFWS (2003). The original source is Nobriga et al. 2001.

Life Stage	Adults
Timing	Pre-VAMP (February 1 through April 15)
Concerns	1) High relative densities of adults in the south Delta are a concern due to the potential for increase entrainment at the SWP and CVP. 2) High relative densities of delta smelt in the south Delta also suggest spawning may occur in the south Delta, increasing the chances for exceeding the red light level [a] of incidental take in the late spring and early summer.
Data of Interest	Before pre-VAMP, consider fall midwater trawl indices Spring midwater trawl Salvage Beach Seine Chipps Island trawl Hydrology (wet or dry year; placement of X2) Water quality conditions and water temperature Condition of the fish
Assessment of Conditions	Adult distribution in Delta and downstream of the Delta Salvage levels/densities, yellow light Potential high numbers in juvenile salvage if high numbers of adults are concentrated in the south Delta
Tools for Change	Reduction of exports, either concurrently at both facilities or at the facility that is salvaging the most fish
Biological Questions Using the Available Data	1) Is the adult distribution broad or not? 2) Is salvage elevated or not? 3) Is previous FMWT index high or low? 4) Are water quality conditions (e.g. water temperatures) conducive to spawning? 5) Are fish ripe for spawning? (Both of above may help determine if there will be a protracted spawn.)
Questions Concerning Operations	1) Is there a need to reduce exports at either or both facilities based on either the distribution of adults and/or an increase in the salvage of adult delta smelt? 2) Is it likely to be a difficult spring or summer? That is, do we expect high levels of delta smelt salvage in the spring or summer?
Assessment of Concern	I. If the stated recovery criteria index is lower than 239, then concern is high. II. If distribution information shows adults delta smelt are concentrated in the couth and central Delta, then concern is high. III. If the observed or predicted salvage of adults increases sharply, then concern is high. IV. If fish at the salvage facilities are on the verge of spawning and temperatures are conducive to spawning, then concern is high.
Recommendations	A) If concern is high and salvage increases abruptly, then recommendations for action is likely. B) If the observed or predicted salvage is at or approaching the red light

	or at the yellow light, then a recommendation for action is likely. C) If assessments II and I are true, then we expect a difficult spring or summer (June and July).
Life Stage	Larvae
Timing	VAMP (April 15 through May 15)
Concerns	High numbers of larvae in the south Delta will likely result in higher numbers of fish rearing to juvenile stages and higher levels of entrainment
Data of Interest	Light traps surveys 20-mm survey[b] Water temperatures Salvage[c] Hydrology (wet or dry year: placement of X2)
Assessment of Conditions	Spawning distribution Percent distribution Timing: start and duration of spawning Implement model to predict future salvage (end of VAMP) Water quality conditions, water temperature
Tools for Change	Change in San Joaquin River flows Change in export reductions (1-3 = net flow) Change in barrier operations
Biological Questions Using the Available Data	1) Is the distribution of spawning broad or restricted? 2) Is larval distribution broad or restricted? 3) When does spawning occur? 4) Do we expect punctuated or protracted spawning? 5) Do we expect SWP and CVP to reach red light salvage levels?
Questions Concerning Operations	Do we consider changing net flows in Old and Middle rivers?
Assessment of Concern	I. If light trap results demonstrates that spawning has occurred in the south Delta, then concern is high. II. If the 20-mm survey shows 50% of the delta smelt are in the zone of influence (e.g., east of the confluence), then concern is high. III. If abundance in the 20-mm survey is low relative to other years, then concern is high. IV. If substantial larval recruitment is expected to occur in the south and central Delta post-VAMP, then concern is high.
Recommendation	If concern is high and salvage is at or approaching red light or at yellow light, then recommendations to improve net flow in Old and Middle Rivers are likely. (This recommendation applies during VAMP and post-VAMP, although the tool used will vary.)
Life Stage	Juveniles
Timing	Post-VAMP (May 15 through July 1)
Concerns	High numbers of delta smelt juveniles in the south and central Delta will likely result in increased entrainment when export levels increase at the end of VAMP.
Data of Interest	20-mm survey[b] Salvage Summer townet

	Hydrology (wet or dry year: placement of X2) Export rates
Assessment of Conditions	Percent of the distribution outside of the zone of influence (e.g., east of the confluence) Salvage level (number) Salvage density
Tools for Change	Change in exports Change in agricultural barrier operations[d] Removal of HORB[d] Position of cross-channel gates Flow changes in San Joaquin, Old, and Middle rivers
Biological Questions Using the Available Data	1) What is the relative distribution in and outside the zone of influence (e.g. upstream and downstream of the confluence)? 2) Is abundance high? 3) Is salvage at or approaching red light or at yellow light? 4) Are fish migrating west from the Delta?
Questions Concerning Operations	1) Do we consider changing exports? 2) Do we consider changing the agricultural barrier/HOB operations?[e] 3) Do we consider changing the position of the cross-channel gates after May 20?
Assessment of Concern	I. If the 20-mm survey shows 50% of the delta smelt are in the zone of influence (e.g. east of the confluence), then concern is high. II. If abundance in the 20-mm survey is low, relative to other years, then concern is high.
Recommendation	If concern is high and salvage is at or near red light, then recommendation for action is likely.

[a] Yellow light and red light as defined in the 1995 OCAP opinion.
[b] If fortnightly 20-mm survey is occurring and red light occurs, then effort will increase to weekly sampling.
[c] Salvage levels at this time will likely not reflect the number of delta smelt in the south Delta, since smelt
begin to be counted at the facilities at about 25 mm.
[d] The barriers shall be operated as stated in the USFWS biological opinion (1-1-96-F-53), April 26, 1996.
[e] Changes considered under "a" and "b" would aim to increase net positive flows in Old and Middle rivers downstream of the export facilities.

Figure 6. The delta smelt risk assessment matrix with annotations from USFWS (2004).

Delta smelt Risk Assessment Matrix (DSRAM)

Life Stage	Adults	Adults	Adults	Adults and larvae	Adults and larvae	Larvae and juveniles	Larvae and juveniles	Juveniles
Previous Year's Fall Midwater Trawl Recovery Index (1)	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74
Risk of Entrainment (2)				X2 upstream of Chipps Island and temps are ≥12°	X2 upstream of Chipps Island and temps are between 12° and 18°C	X2 upstream of Chipps Island and mean delta-wide temps <18°C and south delta temps below 25°C	X2 upstream of Chipps Island and temps are below 25°C	X2 upstream of Chipps Island and temps are below 25°C
Duration of Spawning period (number of days temperatures are between 12 and 18°C) (3)					39 days or less by April 15	50 days or less by May 1		
Spawning Stage as determined by spring Kodiak trawl and/or salvage (4)			Presence of Adults at spawning stage ≥4	Adult spawning stage ≥4	Adult spawning stage ≥4			
smelt distribution (5)	See footnote #5	See footnote #5	See footnote #5	See footnote #5 or negative 20mm centroid or low juvenile abundance	Negative 20mm centroid or low juvenile abundance	Negative 20mm centroid or low juvenile abundance	Negative 20mm centroid or low juvenile abundance	Negative 20mm centroid or low juvenile abundance
Salvage Trigger (6)	Adult concern level calculation	Adult concern level calculation	Adult concern level calculation	Adult concern level calculation		If salvage is above zero	If salvage is above zero	

Tools for Change (7)	December	January	February	March	April	May	June	July
Export reduction at one or both facilities	X	X	X	X	X	X	X	X
Change in barrier operations						X	X	X
Change in San Joaquin River flows				X	X	X	X	X
Change position of cross channel gates						X	X	

Delta Smelt Risk Assessment Matrix Footnotes (note: the references for the DSRAM are also included

in the literature cited section of the biological opinion). Refer to USFWS (2004) for supporting graphics and data referenced below.

[1] The Recovery index is calculated from a subset of the September and October Fall Midwater Trawl sampling (htt~://www.delta.df~.ca.~ov/). The number in the matrix, 74, is the median value for the 1980-2002 Recovery Index (Figure DS 1)

[2] The temperature range of 12 to 18 degrees Celsius is the range in which most successful delta smelt spawning occurs. This has been analyzed by using observed cohorts entering the 20-mm Survey length frequency graphs (1 996-2002). Cohorts were defined by having a noticeable peak or signal and occurring over three or more surveys during the rearing season. Back calculations were made using the first survey of that cohort with fish less than 15 mm fork length. Temperature data from IEP's HEC-DSS Time Series Data web site was compiled using three

stations representing the south Delta (Mossdale), confluence (Antioch), and north Delta (Rio Vista) and averaged together. Spawning dates for each cohort were back-calculated by applying an average daily growth rate (wild fish) of 0.45 mrnlday (Bennett, DFG pers. comm.) and egg incubation period of 8-14 days (Baskerville-Bridges, Lindberg pers. comm.)(Mager et al. 2004) from the median value of the analyzed cohort. Each spawning event was then plotted 1 against temperature over time (Figure DS2.1). While spawning does occur outside of the 12-18 degree range, larval survival is most likely reduced when temperatures are either below (DFG pers. comm.) or above this range (Baskerville-Bridges & DFG pers. comm.). Critical thermal maxima for delta smelt was reached at 25.4 degrees Celsius in the laboratory (Swanson et al., 2000); and at temperatures above 25.6 degrees Celsius smelt are no longer found in the delta (DFG, pers. comm.). Websites for the temperature data: http://iep.water.ca.gov/cgibin/dss/dss 1 .pl?station=RSAN007

http://iep.water.ca.gov/cgibin/dss/dssl .pl?station=RSAN087

http://iep.water.ca.gov/cgibin/dss/dss 1 .pl?station=RSAC 101

Mager RC, Doroshov SI, Van Eenennaam JP, and Brown RL. 2004. Early Life Stages of Delta Smelt. American Fisheries Society Symposium 39: 169-1 80.

Swanson C, Reid T, Young PS, and Cech JJ. 2000. Comparative environmental tolerances of threatened delta smelt (Hypomesus transpaclficus) and introduced Wakasagi (H. nipponensis) in an altered California estuary. Oecologia 123:384-390.

[3] Figure DS3: The working hypothesis for delta smelt is that spawning only occurs when temperatures are suitable during the winter and spring. In years with few days having suitable spawning temperatures, the spawning "window" is limited, so the species produces fewer cohorts of young smelt. When there are fewer cohorts the risk that mortality sources such as entrainment may substantially reduce population size increases. The figures below were used Operations Manager 101 to help define years when there were relatively few days with suitable temperatures. For April 15 and May 1, the figures show the cumulative spawning days for each year during 1984-2002. The cumulative spawning days for each year were calculated based on the number of days that the mean water temperature for three Delta stations (Antioch; Mossdale and Rio Vista) was in the 12 - 18 C range starting on February 1. The results are plotted in terms of the ranks to identify the lower quartile. In other words, years in the lower quartile represent examples of

years with relatively few spawning days.

[4] The adult spawning stage is determined by the Spring Kodiak Trawl andfor fish collected at the salvage facilities (http://www.delta.dfg.ca.gov/). A stage greater than or equal to 4 indicates female delta smelt are ripe and ready to spawn or have already spawned (Mager 1996).

Mager RC. 1996. Gametogenesis, Reproduction and Artificial Propogation of Delta Smelt, Hypomesus transpaczjkus. [Dissertation] Davis: University of California, Davis. 115 pages. Published.

[5] The spring kodiak trGl will be used to generally evaluate the distribution of adult delta smelt. However, since the spring kodiak trawl is not intended to be a survey for abundance or distribution, no definitive trigger for concern can be determined at this time.

Juveniles (March-July) - distribution of juvenile delta smelt where the centroid is located upstream (negative) or downstream (positive) of the Sacramento-San Joaquin River confluence

(Sacramento RKI 81 ; Figure DS5.1). The 20-mm Survey centroid is calculated by multiplying the observed delta smelt station CPUE (fish11 0,000 m3) by a distance parameter in km from Sacramento RKI 81. The summed result (summed over a survey) is divided by the survey CPUE which gives the survey centroid position (Figure DS5.2). Low juvenile abundance will also be a trigger. When juvenile abundance is low, concern is high. Low abundance is indicated when the total cumulative catch in the 20-mm Survey is less than or equal to the 1995-2003 median value of cumulative 20-mm Survey catch for the same surveys (Table DS5).

[6] Adult salvage trigger: the adult delta smelt salvage trigger period is December through March and the trigger is calculated as the ratio of adult delta smelt salvage to the fall MWT index. This ratio will increase as fish are salvaged during the winter months. If the ratio exceeds the median ratio observed during December-March 1980-2002, then the trigger has been met (see Figure DS6 for more explanation of the calculation) Juvenile salvage trigger: During May and June, if delta smelt salvage at the SWP/CVP

facilities is greater than zero, then the working group will meet. This is because May and June are the peak months of delta smelt salvage and salvage densities cannot be predicted. Therefore, during these two months, the delta smelt working group expects to meet regularly to look at relevant information such as salvage, delta temperatures, delta hydrology and delta smelt distribution and decide whether to recommend proactive measures to protect these fish.

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[7] The tools for change are actions that the working group can recommend to the WOMT to help protect delta smelt. Exports may be reduced at one or both of the south delta export facilities and a proposed duration of the reduction would be recommended by the working group. Export reductions and changes in San Joaquin River flows may be covered by B(2) or EWA assets. Details of past fish actions can be found at the Calfed Ops website: http://wwwoco.water.ca.novlcalfedops/index.html; >Operations [year]

Figure 7. A proposed comprehensive evaluation framework for EWA (Hymanson et al. 2003).

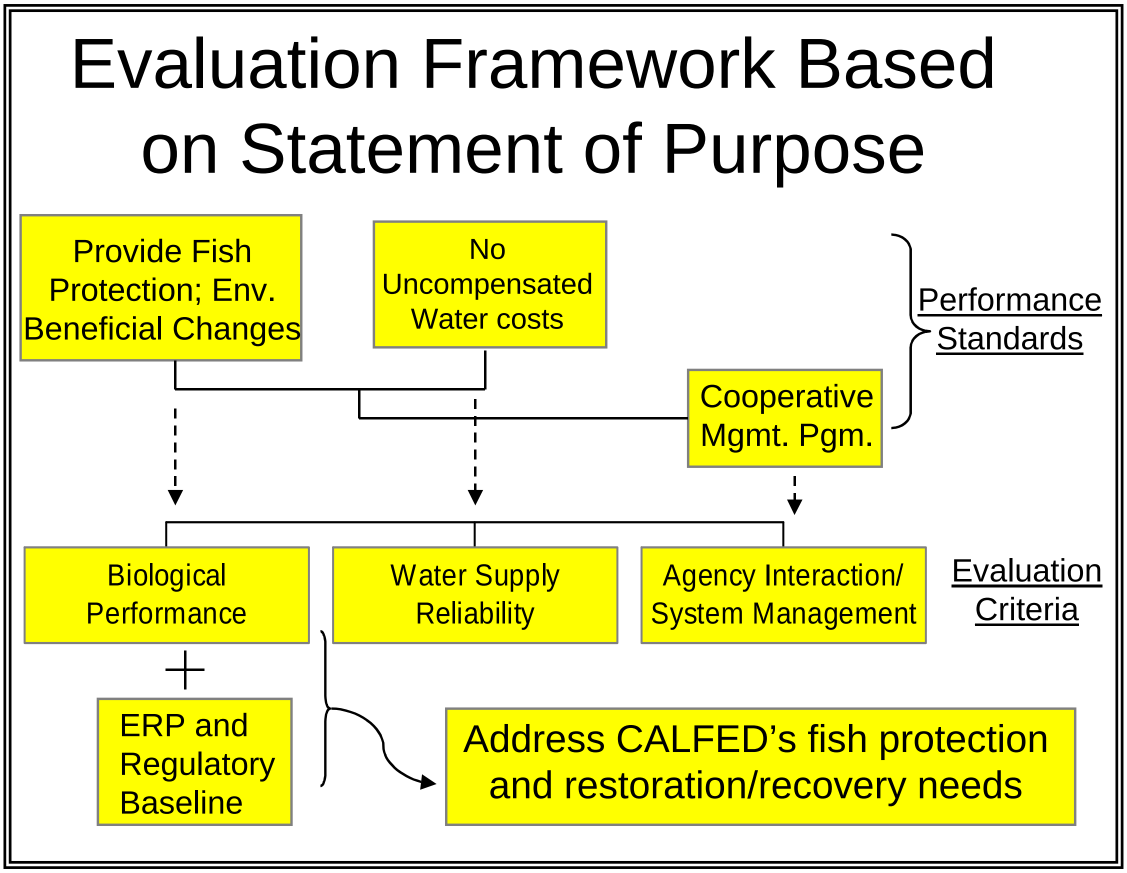


Figure 8. A revised comprehensive evaluation framework for EWA, modified from Hymanson et al. (2003).

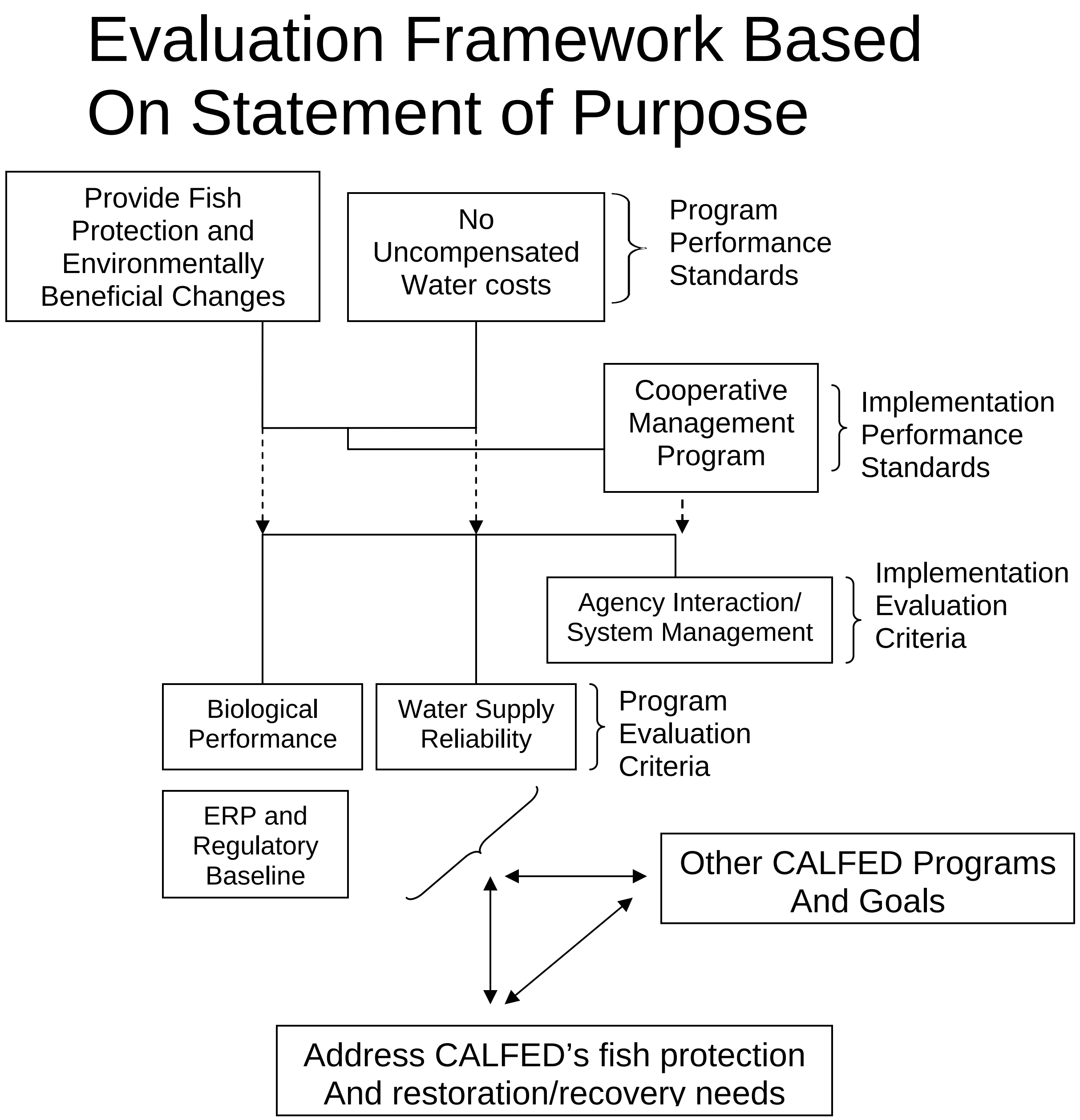
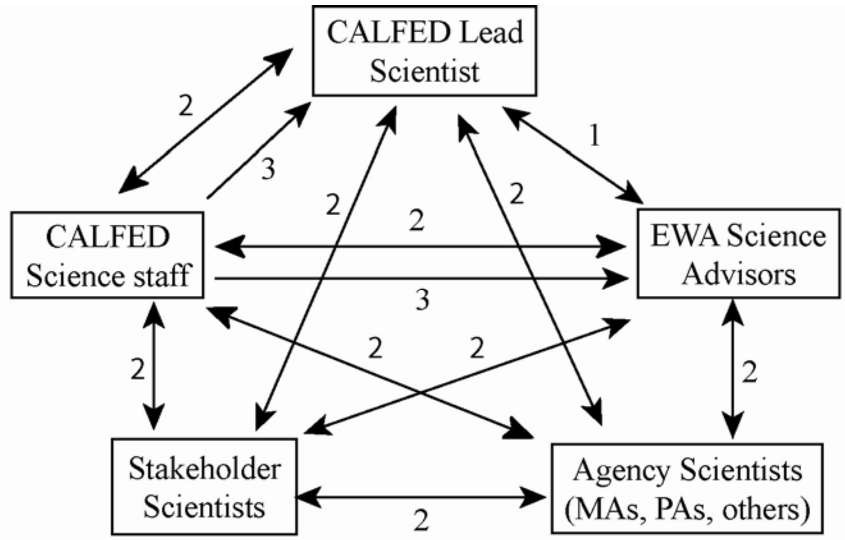


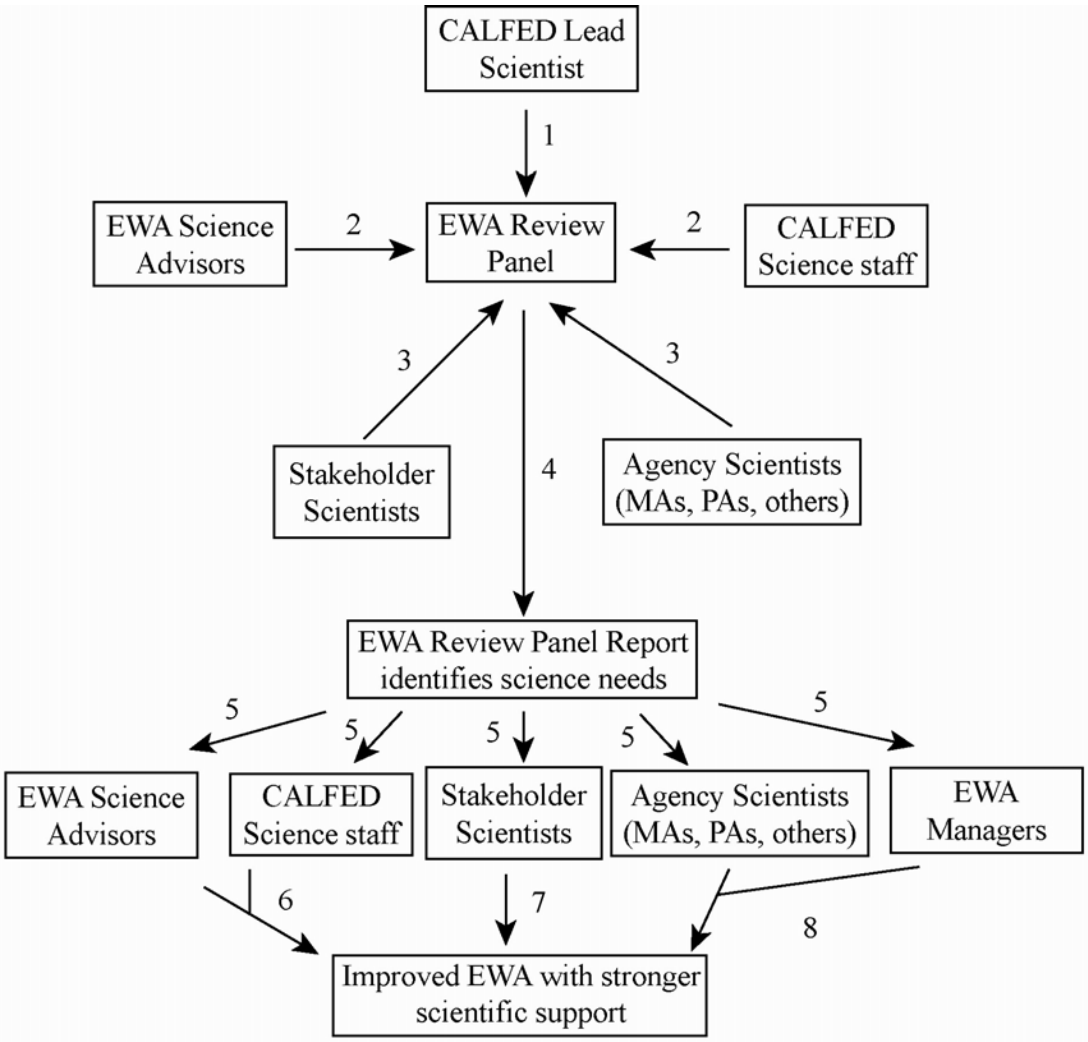
Figure 9. An idealized summary of the major pathways of scientific information within EWA.



Typical *major* pathways of scientific information exchange:

1. EWA Science advisors have a specific charge to keep the Lead Scientist informed, particularly when fish actions are imminent.
2. Information exchanged among scientists informally and at workshops. Academic scientists and specialists on CALFED staff are also important participants.
3. CALFED Science staff provide logistical support for the Lead Scientist and EWA Science Advisors, particularly the production of reports and other documentation.

Figure 10. Flow chart for the EWA annual review.



Major information pathways associated with the EWA Review Panel:

1. Lead Scientist convenes the panel and provides charge.
2. CALFED Science staff and EWA Science Advisors prvide logistic and scientific support.
3. EWA scientists report on fish actions and assessment of results. Agency and other scientists report research findings with a bearing on EWA issues. Information is provided as written documents before the panel convenes with oral presentations during the meeting.
4. The EWA Review Panel produces a report that identifies the science needs of the EWA and assesses the performance of EWA in the previous year.
5. The report is distributed for action.
6. EWA Science Advisors and staff organize workshops on science needs. Staff experts work on issues as time allows.
7. Academic and other scientists continue research but no funding is available directly from EWA.
8. EWA managers identify tasks for agency scientists. The time available for such tasks is minimal, especially for biologists with duties other than EWA.